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RECONNAISSANCE STUDY ON

POTENTIAL HYDROELECTRIC PROJECTS

NEVADA CREEK
RUBY DAM
MIDDLE CREEK
COONEY DAM
TONGUE RIVER
DEADMAN'S BASIN

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

TUDOR ENGINEERING COMPANY
SAN FRANCISCO, CALIFORNIA

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PRELIMINARY FEASIBILITY REPORT
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SECTION I

SUMMARY

A. GENERAL

The Montana Hydroelectric Reconnaissance was conducted during June and July of 1982 in order to make a preliminary determination of the technical, economic, and environmental feasibility of installing hydroelectric facilities at each of six existing state owned reservoirs. The sites studied included a 500 kW installation at Nevada Creek Dam; a 3,750 kW installation at Ruby Dam; a 650 kW installation at Middle Creek Dam; an 800 kW installation at Cooney Dam; a 2,175 kW installation at Tongue River Dam; and a 1,600 kW installation at Deadman's Basin. The locations of the potential projects are shown on Figure I-1. The overall results of the study are presented below, as well as recommendations for future actions regarding these projects. Each project is addressed in greater detail in the appropriate section of this report.

B. RESULTS

Significant physical features of the six potential projects are summarized on Table I-1. Significant economic features of the projects are summarized on Table I-2. All six of the projects are technically feasible. The Nevada Creek and Middle Creek projects have benefit/cost (B/C) ratios of less than one and would not be economically feasible projects. The remaining four projects have B/C ratios greater than one and would be economically feasible projects. The Tongue River, Deadman's Basin and Ruby Dam Projects would probably have revenues greater than costs, indicating a positive cash flow, during the second year of operation; and the Cooney Dam Project would probably produce a positive cash flow by the third year of

operation. There are no apparent environmental constraints of any of the projects that would be prohibitive to development. Environmental impacts associated with the projects would be very minimal.

C. RECOMMENDATIONS

The Tongue River, Deadman's Basin, Ruby Dam, and Cooney Dam projects are viable projects and their development is recommended. The Tongue River Project should probably be developed first and all four projects should probably be developed before 1990. More detailed feasibility studies of the four sites and applications for Federal Energy Regulatory Commission Licenses or Exemptions are recommended immediate actions. No further action is recommended for the Middle Creek and Nevada Creek projects.

TABLE I-1

SUMMARY OF PHYSICAL FEATURES
MONTANA HYDROELECTRIC RECONNAISSANCE

Project Name	Installed Capacity (kW)	Average Annual Energy Production (GWh)	Average Annual Plant Factor (%)	Turbine Type
Nevada Creek Hydroelectric Project	500	1.3	29	Horizontal Francis
Ruby Dam Hydroelectric Project	3750	9.5	29	2-Horizontal Francis
Middle Creek Hydroelectric Project	650	1.9	33	Horizontal Francis
Cooney Dam Hydroelectric Project	800	4.5	64	Horizontal Francis
Tongue River Hydroelectric Project	2175	11.5	61	Tubular
Deadman's Basin Hydroelectric Project	1600	8.6	61	Horizontal Francis

TABLE I-2

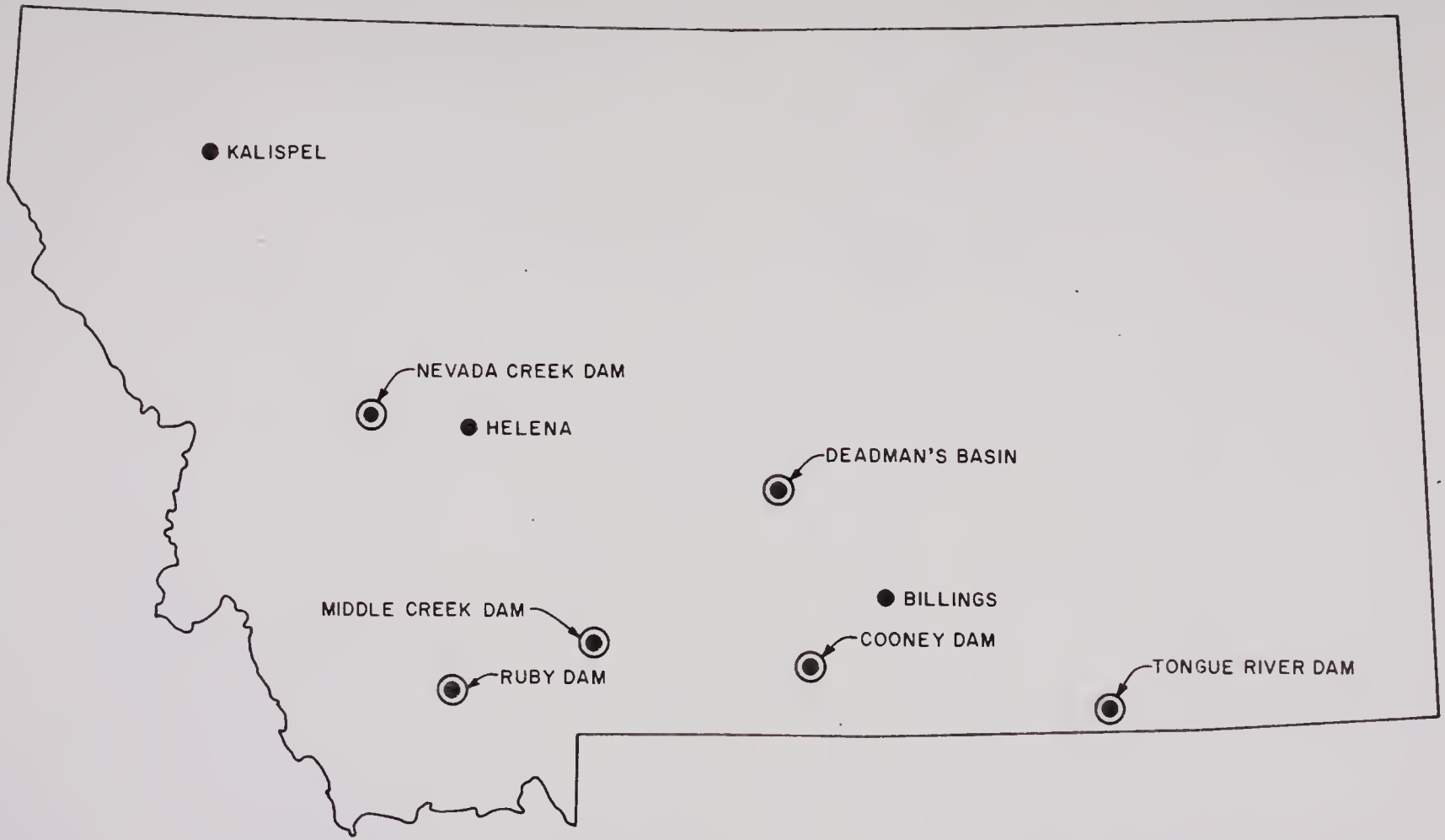
SUMMARY OF ECONOMIC FEATURES
MONTANA HYDROELECTRIC RECONNAISSANCE

Project Name	Capital [1/] Cost ($)	Annual Cost ($)	Production Cost (Mills/kWh)	Benefit/ Cost Ratio
Nevada Creek Hydroelectric Project	1,989,000	259,400	201	0.56
Ruby Dam Hydroelectric Project	5,054,800	659,000	70	1.63
Middle Creek Hydroelectric Project	2,948,200	384,400	207	0.63/0.55
Cooney Dam Hydroelectric Project	2,563,500	334,200	74	1.53
Tongue River Hydroelectric Project	5,941,800	726,700	67	1.68
Deadman's Basin Hydroelectric Project	4,404,100	566,900	66	1.69

[1/] July 1984

FIGURE

I-1



STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

LOCATION MAP

FIGURE

I-1

SECTION II

METHODOLOGY AND ASSUMPTIONS

A. GENERAL

The methodology and assumptions used to analyze the State of Montana's six potential hydroelectric sites are presented below. This analysis was conducted at a conceptual level with the primary purpose of identifying viable projects for continued investigation. The details of the analysis for each site are presented in the appropriate sections of the following report.

B. HYDROLOGY AND HYDRAULICS

The flows and heads available for power production at each site were based on historical records of discharge and water surface elevations. With the exception of the Deadman's Basin Project, it was assumed that the pattern of flow releases at each site would remain unaltered. The possibility of increasing the total amount of water diverted to Deadman's Basin was considered.

Historical gage records for monthly outflows and end of month reservoir levels were provided by the United States Geological Survey (USGS) and the State of Montana Department of Natural Resources and Conservation (DNRC) for each site. Representative years were selected from these records and used to develop average annual monthly hydrographs and monthly reservoir levels for each site.

Estimates of the tailwater rating curve for each site were prepared assuming that a low weir would be placed downstream from each project to control the tailwater.

. The capacity of the existing outlet works was maintained by the proposed installation at all sites but the Tongue River and Cooney Dam. The outlet capacity at the Tongue River was reduced because the tunnel serving as the current outlet works is very large and the cost of lining the entire tunnel to withstand pressure would be prohibitive. The Dam safety report (1980) for this site indicates that passing high flows through this tunnel is not advisable in any case. The full outlet capacity was not maintained at Cooney Dam because the dam and spillway were recently rehabilitated and the spillway should now have adequate capacity to pass flood flows.

The hydrology and hydraulics associated with each site are addressed more thoroughly in the appropriate sections of this report.

C. POWER STUDIES

The flows and heads available for power production at each site were used to estimate the type and number of turbines, installed capacity, and average annual energy generation for each site. This calculation was based on typical turbine performance characteristics. The turbine capacities were not optimized; however, an attempt was made to select a turbine configuration for each site that could utilize a wide range of the available heads and flows. The turbine selection for each site is presented in more detail in the appropriate sections of the report.

D. COST ESTIMATES

The total project capital cost for each site consists of the direct construction cost; associated indirect costs for engineering, management, and administration; and interest during construction. The cost estimates are based on bid prices

for similar construction work, recent manufacturers quotes for mechanical and electrical equipment, and experience with other projects. The estimates also include allowances for contingencies and the cost of engineering. The contingency allowance is 15 percent of the mechanical and electrical costs plus 20 percent of all other costs. The engineering costs cover activities which include detailed feasibility studies, obtaining miscellaneous licenses and permits, final design, contract plans and specifications, and engineering services during construction. This amount was estimated as 25 percent of the direct construction cost plus contingencies. An allowance was also made for owner administration, financial, and legal expenses. Interest during construction was based on an 18-month construction period and 12 percent interest. All cost estimates are presented at July 1982 price levels. These cost estimates were escalated to July 1984 at eight percent annual interest for purposes of economic analysis.

E. POWER VALUES

The value of power in Montana was assumed to be similar to the published avoided costs of the Montana Power Company (MPC). The MPC avoided cost for 1982 has two components: an energy payment and a capacity payment. The energy payment for 1982 is 40.9 mills/kWh; the capacity payment is based on the installed capacity and the plant factor at each site. For the six sites being investigated, this capacity value is roughly equivalent to about 10 mills/kWh. The current value of energy in Montana is about 50 mills/kWh for small hydroelectric sites.

Based on the assumption that energy prices would inflate at about 10 percent per year for 10 years and then level off, and that the discount rate is 12 percent, a levelized power cost was developed for a 50-year period. This levelized cost is about 90 mills/kWh; based on this calculation, it would be reasonable to assume that power could possibly be sold in

Montana at a levelized rate of about 75 mills/kWh. The difference in the actual levelized value and the value on the market would provide the incentive for a power purchaser to offer a levelized cost.

For purposes of this analysis, it has been assumed that the value of power at all six sites is 45 mills/kWh for 1982.

F. ECONOMIC ANALYSIS

The costs and benefits associated with each project were analyzed in order to determine the economic feasibility of installing hydroelectric facilities. The analysis was based on the following assumptions:

1. The capital costs associated with each project were estimated at the July 1982 price level.

2. In order to compare all projects on an equal basis, all six projects were assumed to begin operation in January 1986.

3. The economic life of the project is 50 years. This project life begins with the on-line date of January 1986 and ends with December 2035.

4. The projects would require 18 months to build. Construction would begin during July 1984.

5. The general rate of inflation is eight percent.

6. The rate of escalation of the cost of energy is 10 percent.

7. Prices will increase for 10 years after the project goes on-line, then remain at a constant level.

8. Capital costs were inflated from July 1982 to the proposed bid date of July 1984 at eight percent.

9. Interest during construction (IDC) was calculated for the 18-month construction period and added to the inflated capital cost to determine the value of the capital cost at the proposed on-line date. No credit for interest income on retained funds was allowed, making the calculation of IDC conservative.

10. Operation and maintenance (O&M) for the first year of operation would be equal to 1.25 percent of the direct construction cost plus contingencies. This is consistent with Bureau of Reclamation practice.

11. The cost of O&M would inflate at eight percent annually for ten years and then remain constant for the remainder of the period of economic analysis.

12. The project would be financed with bonds bearing an interest rate of 12 percent and having a 35-year life.

13. The total annual cost of the project would be the sum of debt service on the bonds and O&M.

14. The value of power for 1982 is 45 mills/kWh. This value would escalate at 10 percent annually for 10 years after the project goes on line, then remain constant.

15. All costs and benefits were discounted to January 1986 at 12 percent interest.

16. The benefit/cost ratio is the ratio of present worth of benefits to present worth of costs.

The results of the economic analysis of each site are presented in the appropriate sections of the report.

NEVADA CREEK DAM AND RESERVOIR

NEVADA CREEK DAM OUTLET WORKS

SECTION III

NEVADA CREEK HYDROELECTRIC PROJECT

A. GENERAL

The Nevada Creek Hydroelectric Project would be located at Nevada Creek Dam, a low earthfill structure on Nevada Creek approximately 8.5 miles southeast of Helmville in Powell County, Montana. The dam was constructed for sedimentation, recreation, irrigation, and flood control purposes. The proposed hydroelectic project would utilize flow releases through the dam outlet works to produce an average of approximately 1.3 million kilowatt-hours annually.

B. EXISTING FACILITIES

The main features of the Nevada Creek Project are the dam, reservoir, spillway, and outlet works. Additional existing features significant to the development of a hydroelectric project include access to the site and the existence of electrical transmission lines. The existing facilities are described in more detail below. The arrangement of the facilities is shown on Figure III-1.

1. Dam

Nevada Creek Dam is a zoned earthfill embankment with a maximum structural height of 105 feet and a crest length of 1,183 feet at elevation 4,628 feet. The dam has a crest width of 25 feet and was placed on a slope of 2:1 on the upper section and 3:1 on the lower section.

The spillway is an ogee crest with a concrete chute located at the left abutment of the dam (looking downstream). The spillway drops about 88 feet over a distance of about 500

feet. The spillway crest elevation is 4,616 feet. The spillway is 100 feet wide at the crest and tapers to about 30 feet in width at the stilling basin. The Dam Safety Report (1981) indicates that the spillway is in a deteriorated condition and has inadequate hydraulic capacity.

The outlet works is located to the right abutment of the dam. The intake invert is at elevation 4,547.5 and the outlet invert is at elevation 4,547.0. The flow is controlled by two 54-inch gate valves in a control tower near the center of the dam. The outlet works is a five-foot diameter reinforced concrete conduit. The total length of the conduit is 390 feet; of this total, 220 feet are upstream from the control valves and are pressurized while the remaining 170 feet are downstream from the gates and operate under an open channel flow condition. The Dam Safety Report indicates that the gates, some sections of the conduit, and the stilling basin are in need of minor repair.

The description presented above reflects the existing conditions at the dam. For purposes of this report, no attempt has been made to determine the effects of modification of the facilities in response to the Dam Safety Report.

2. Site Access

An existing paved road currently provides access to Nevada Creek Dam. An existing dirt road provides access to the outlet works. This road would provide adequate access to the powerhouse location for construction, operation, and maintenance of the project.

3. Transmission Lines

During the June 4, 1982 field trip to the Nevada Creek site transmission lines were observed within one-half mile of the

proposed powerhouse location. It is anticpated that transmission lines with adequate capacity for the transmission of power from the Nevada Creek Project exist in the immediate area of the project. The project is in the Montana Power Company service area. The area is also served by the Missoula Electric Coop. In addition to the transmission lines observed during the field trip, two 500 kV lines owned by the Montana Power Company pass within two miles of the project. For purposes of the cost estimate, it was assumed that about one mile of new transmission lines would need to be constructed. The exact location and nature of the interconnection with the existing grid would need to be determined during a detailed feasibility study. Costs associated with transmission lines could include construction of new lines or reconductoring of existing lines. The limited data obtained during this study were not adequate to make this determination.

C. PROPOSED PROJECT

A conceptual level layout of the Nevada Creek Hydroelectric Project was prepared for purposes of demonstrating the overall technical and economic feasibility of the project. No attempt was made to optimize the project configuration. Additional configurations should be considered if any further studies are conducted.

1. Project Description

The proposed Nevada Creek Project would consist of a steel tunnel liner inside the outlet works tunnel downstream from the gatehouse, a powerhouse containing a 500 kilowatt, horizontal Francis turbine, a tailrace, and miscellaneous project features such as a hollow cone low flow bypass and pressure regulation valve, the switchyard, interconnection to the exisiting electrical grid, and a driveway and parking lot. The physical features of the proposed project are summarized on Table III-1.

A low weir downstream from the outlet would be removed and the channel would be excavated back to the powerhouse site at elevation 4540 feet. The powerhouse would be located to the left of the existing outlet. About 150 feet of steel conduit liner would be required; the largest size of liner that could be installed inside the conduit would be used. This conduit liner would be about four feet in diameter. Reduction of existing outlet capacity would be minimal.

The steel liner would extend below the outlet works far enough to allow room for a bifurcation and a fixed wheel gate. The gate would be opened when it is necessary to discharge large flows for flood control. The penstock to the powerhouse would be 39 inches in diameter. A synchronous hollow cone valve would be provided to bypass flows and alleviate pressure surges in the event of an emergency shutdown.

The physical features of the proposed project are summarized as Table III-1 and are shown graphically on Figure III-1.

2. Hydrology and Hydraulics

Nevada Creek is a tributary of the Blackfoot River, which is part of the Snake/Columbia River system. Nevada Creek Dam is located seven miles west of Finn, Montana. The Montana Department of Natural Resources and Conservation (DNRC) maintains a stream gage on the river below the dam and a reservoir level gage upstream from the dam.

The discharge downstream from the dam is recorded by DNRC stream gage 76F02000, "Nevada Creek below Nevada Creek Reservoir, near Helmville, Montana." The total drainage area above the site is 145 square miles, and the altitude of the

gage is 4,545 feet. Published flow records used in this study are from January 1966 to December 1976. The maximum and minimum discharges over the period of record were 911 cfs on June 20, 1975 and zero flow several times a year. The outflow from the reservoir varies on a seasonal basis, with no or little flow being released from November through March each year. The average discharge over the period of record was 32,980 acre-feet per season, which is equal to an average annual discharge of about 46 cfs.

The water surface level in the reservoir is recorded by DNRC gage 76F01900, "Nevada Creek Reservoir." Records have been maintained for this reservoir since October 1939, with several years of incomplete records occurring in 1948, 1950-58, 1961-62, 1965-66 and 1969-70. The maximum observed reservoir contents during the 1966 to 1976 period of record were 12,640 acre-feet in May and June 1970, and the minimum content was zero storage from August to October 1973. The total usable storage available in the reservoir is 12,640 acre-feet between the bottom of the outlet elevation 4,551.5 feet, and the spillway crest elevation 4,616 feet. The dead storage, below elevation 4,551.5 feet, is 12 acre-feet.

The existing water surface elevation downstream from the outlet works varies from 4546 feet at zero discharge to elevation 4,550 feet at about 1,000 cfs. As previously mentioned, the existing measuring weir would be replaced by a lower weir as part of this project. The downstream water surface elevation would be lowered by about six feet after this modification.

For the purposes of estimating this site's potential installed capacity, power production, and energy production, the historical records of the reservoir outflows and elevations for the years 1966 through 1976 were used to develop an annual hydrograph of average monthly outflows, and an average monthly

record of water surface elevations. These values are shown graphically on Figure III-2. The average annual flow at the dam site for this period of record was 45.6 cfs. The USGS maintains a stream gage (No. 12335500, "Nevada Creek above Reservoir, near Finn, Montana") about 0.7 miles upstream of the reservoir, with a drainage area of 116 square miles, in which the long-term average discharge (based on 40 years of record) was 38.3 cfs. When this long-term average discharge is adjusted for the 29 square miles of additional drainage area located upstream from the dam, the resultant long-term average discharge at the dam site would be 47.9 cfs. This figure is within five percent of the average annual flow for the 1966 to 1976 period of record, and indicates that the selected hydrograph for the study is representative of the long-term average.

3. Power Study

The average annual hydrograph and average record of monthly water surface elevations described above were used to estimate the installed capacity and annual average energy production for the Nevada Creek Project. This determination was made based on typical turbine performance characteristics and the physical characteristics of the site. The head available for power production was estimated as the difference between the headwater and tailwater elevation minus an allowance for head losses. The capacity of the plant was not optimized; however, an attempt was made to select the turbine so that its operation would encompass a wide variation of head and flow.

A horizontal Francis turbine with a rated head of 66 feet, rated flow of 100 cfs, and rated capacity of 500 kilowatts was selected for the Nevada Creek site. The head available at this site is slightly greater than the maximum normal range for a standardized tube turbine, and fits well into the normal range for Francis turbines. The horizontal configuration offers savings from decreased excavation, and allows for construction

of most of the powerhouse prior to delivery of the turbine. The turbine would produce power for six months in an average year and would produce, on the average, approximately 1.3 million kilowatt-hours annually. The average annual plant factor for the site would be about 30 percent.

A submersible turbine at the upper end of the outlet works may be a viable installation for about 30 percent less cost than the unit considered; however, units of this type have not been widely used and the data on this type of machine is limited. Commercially available units of this type operate to a maximum rated head of about 45 feet and have a maximum rated capacity of around 500 kW. It may be possible to operate a submersible unit at the head available at this site. The use of the submersible configuration provides very substantial savings in civil costs because the only modificaiton of any existing facilities is at the intake of the outlet works, and the powerhouse costs are minimal. This type of installation was not considered in detail.

4. Cost Estimate

The total project capital cost associated with the Nevada Creek Project consists of the direct construction cost; the associated indirect costs for engineering, management and administration; and interest during construction. The cost estimate for the Nevada Creek Project is presented as Table III-2. This cost estimate is based on bid prices for similar construction work, recent manufacturers quotes for mechanical and electrical equipment, and experience with other projects. The estimate also includes allowances for contingencies and for the costs of engineering. The contingency allowance is 15 percent of the mechanical and electrical costs plus 20 percent of all other costs. The engineering costs cover activities which include detailed feasibility studies, obtaining miscellaneous licenses and permits, final design, contract plans and

specifications, and engineering services during construction. This amount was estimated as 25 percent of the direct construction cost plus contingencies. An allowance was also made for owner administration, financial, and legal expenses. Interest during construction was based on an 18-month construction period and 12 percent interest. No allowance was made for possible interest income on retained funds during construction and the calculation of interest during construction is therefore very conservative.

The cost estimate is presented at July 1982 price levels. The estimated total project capital cost for the Project is $1,705,250. This cost would be $1,989,000 if escalated to the proposed bid date of July 1984 at eight percent annual inflation.

5. Economic Analysis

The benefits and costs associated with the Nevada Creek Hydroelectric Project were assessed in order to determine the overall economic feasibility of the project. The project capital cost was escalated to July, 1984, at eight percent annual interest; this is the proposed bid date for the project. The value of power was escalated at ten percent annual interest to January 1986, the proposed on-line date for the project. The difference in the rate of escalation of construction and energy costs reflects an apparent trend of energy costs to escalate at a rate more rapid than general inflation. It was assumed that the project would be financed with bonds having a life of 35 years and bearing a 12 percent interest rate. The cost of operation and maintenance for the first year of operation would be 1.25 percent of the capital cost plus contingencies. The annual cost of the Nevada Creek Project for the first year of operation is summarized as Table III-3. The cost of power production at this site would be more than 200 mills per kWh.

It was assumed that the rate of general inflation is eight percent and that energy would escalate at ten percent annually. Inflation and energy escalation were considered for 10 years beyond the proposed on-line date of January 1986 and then held constant. All costs were discounted to January 1986 at 12 percent annual interest and the present worth of the benefits was compared to the present worth of costs to produce a benefit/cost (B/C) ratio for the project. The B/C calculation is presented as Table III-4 and the economic features are summarized at Table III-5. The B/C ratio for this project is 0.56. This ratio indicates that the project is not economically feasible.

D. ENVIRONMENTAL OVERVIEW

1. Overview

Nevada Creek Dam and reservoir are located in the Blackfoot River Basin in northcentral Montana. It is situated in the Garnet Range on the west bank of the Rocky Mountains in a wide valley with vegetation of sagebrush, pine, and juniper. The project is operated jointly by DNRC and the Nevada Creek Water Users Association for irrigation and flood storage. The normal water surface elevation of the reservoir is 4,617 feet. The reservoir has moderate recreation use as does the creek below the dam.

The reservoir supports a wild population of brown and rainbow trout, whereas Nevada Creek below the dam contains a good population of brown, rainbow, and brook trout.

Water quality in the reservoir is generally good. No dissolved oxygen problems are known to exist and no fish kills have ever been reported there (Workman, pers. commun., 1982). Water quality data taken in June and July of 1980 at the USGS

gaging station (No. 12335500) above the reservoir indicates that dissolved oxygen was greater than 8 mg/l and about 94 percent saturated. Total dissolved solids were measured at about 150 mg/l.

The Water Quality Bureau of the Montana Department of Health and Environmental Sciences has classified Nevada Creek as B-1. Dissolved oxygen and temprature standards for this classification are presented in Table III-6. Some erosion problems have been experienced in the creek below the dam (Workman, pers. commun., 1982).

Some Canada geese and ducks use the reservoir for resting during periods of migration in spring and fall. The reservoir supports only limited waterfowl production.

2. Potential Problems

The environmental characteristics of the site suggest that potential problems would be minimal. In this study, it was assumed that historical outflows would be maintained, the elevation of the intake for the outlet works would not change, and that most of the spilled flow would be diverted through the power plant. This latter change may cause a slight reduction in the concentration of dissolved oxygen in the discharge water, but should not affect the value of the fishery habitat below the dam. Temperature of the discharge water may differ slightly from that of the receiving water, but should stil meet the established water quality standards. Water levels in the reservoir and downstream should not vary from what has been experienced in the past.

When ice covers the reservoir in winter months and water levels are abnormally low, concentrations of dissolved oxygen can fall to critically low levels. Although the proposed project would have no effect on dissolved oxygen concentrations

during winter months, the Water Quality Bureau might require the project to meet the 7 mg/l standard for Nevada Creek. Insufficient information is available to determine whether the project would meet this standard.

The transmission line corridor is expected to be less than one mile long and thus should have no major effect on fish or wildlife habitat. The area is rich in cultural resources, however, and a survey of the route may be required before an exemption application can be filed with FERC.

3. Recommended Action

A hydroelectric project at this site is probably not feasible and no further action is recommended at the present time.

E. CONCLUSIONS AND RECOMMENDATIONS

A conventional hydroelectric project at Nevada Creek Dam is probably not feasible. Some unusual configuration, such as a submerged turbine at the upstream end of the outlet works, might be feasible; however, a power plant at this site may not operate often enough to justify any installation. It is recommended that the Department postpone any hydroelectric development at Nevada Creek Dam indefinitely.

TABLE III-1

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF PHYSICAL FEATURES
NEVADA CREEK HYDROELECTRIC PROJECT

Turbine Type:	Horizontal Francis
Turbine Capacity:	500 kW (one unit)
Rated Head:	66 ft
Rated Flow:	100 cfs
Average Annual Energy:	1.3 GWh

TABLE III-2

MONTANA HYDROELECTRIC RECONNAISSANCE
PROJECT CAPITAL COSTS

NEVADA CREEK HYDROELECTRIC PROJECT

	Item	Cost
1.	Structures and Improvements	$ 312,750
2.	Reservoirs, Dams and Waterways	244,200
3.	Turbines and generators	240,000
4.	Accessory Electrical Equipment	75,000
5.	Miscellaneous Mechanical Equipment	15,000
6.	Switchyard	15,000
7.	Transmission Lines	30,000
	Direct Construction Cost	931,950
	Contingencies	169,100
	Subtotal	1,101,050
	Engineering (25%)	275,300
	Subtotal	1,376,350
	Administrative, Legal, and Financial (5%)	68,800
	Subtotal	1,445,150
	Interest During Construction	260,100
	TOTAL PROJECT CAPITAL COST (July, 1982)	1,705,250
	TOTAL PROJECT CAPITAL COST (Escalated to July 1984 at 8% compounded annually)	$1,989,000

TABLE III-3

ESTIMATED ANNUAL COST

NEVADA CREEK HYDROELECTRIC PROJECT

1.	Total Project Capital Cost escalated to July, 1984		$1,989,000
2.	Estimated Cost of Capital:	12%	
3.	Economic Life of Project:	50 Years	
4.	Annual Costs		
	4.1 Amortization Cost[1/]		243,300
	4.2 O, M & R[2/]		16,100
			$ 259,400
5.	Estimated Average Annual Generation		
	1,290,000 kWh/Annum		
6.	Unit Cost of Power [3/]		

$$\frac{\$\ 259,400}{1,290,000} \times 1,000 = 201.1 \text{ mills/kWh}$$

1/ Amortized for 35 years at 12%.

2/ 1.25% of Capital Cost plus contingency, escalated to July 1984 at 8% annual inflation.

3/ First year of operation (1986).

TABLE III-4

Benefit/Cost Analysis - Tudor Engineering Company

NEVADA CREEK HYDROELECTRIC PROJECT - STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

JULY 1982

Year	Cost Streams		Benefit Stream (*)	Present Worth Factor (*)	Present Worths	
	Debt Service	OM&P (*)			Cost	Benefit
1986	243300	16100	85100	1.00000	259400	85100
1987	243300	17400	93700	0.89286	232800	83600
1988	243300	18800	103000	0.79719	208900	82100
1989	243300	20300	113300	0.71178	187600	80700
1990	243300	21900	124700	0.63552	168500	79200
1991	243300	23700	137100	0.56743	151500	77800
1992	243300	25500	150800	0.50663	136200	76400
1993	243300	27600	165900	0.45235	122500	75100
1994	243300	29800	182500	0.40388	110300	73700
1995	243300	32200	200800	0.36061	99300	72400
1996	243300	32200	200800	0.32197	88700	64600
1997	243300	32200	200800	0.28748	79200	57700
1998	243300	32200	200800	0.25668	70700	51500
1999	243300	32200	200800	0.22917	63100	46000
2000	243300	32200	200800	0.20462	56400	41100
2001	243300	32200	200800	0.18270	50300	36700
2002	243300	32200	200800	0.16312	44900	32700
2003	243300	32200	200800	0.14564	40100	29200
2004	243300	32200	200800	0.13004	35800	26100
2005	243300	32200	200800	0.11611	32000	23300
2006	243300	32200	200800	0.10367	28600	20800
2007	243300	32200	200800	0.09256	25500	18600
2008	243300	32200	200800	0.08264	22800	16600
2009	243300	32200	200800	0.07379	20300	14800
2010	243300	32200	200800	0.06588	18100	13200
2011	243300	32200	200800	0.05882	16200	11800
2012	243300	32200	200800	0.05252	14500	10500
2013	243300	32200	200800	0.04689	12900	9400
2014	243300	32200	200800	0.04187	11500	8400
2015	243300	32200	200800	0.03738	10300	7500
2016	243300	32200	200800	0.03338	9200	6700
2017	243300	32200	200800	0.02980	8200	6000
2018	243300	32200	200800	0.02661	7300	5300
2019	243300	32200	200800	0.02376	6500	4800
2020	243300	32200	200800	0.02121	5800	4300
2021	0	32200	200800	0.01894	600	3800
2022	0	32200	200800	0.01691	500	3400
2023	0	32200	200800	0.01510	500	3000
2024	0	32200	200800	0.01348	400	2700
2025	0	32200	200800	0.01204	400	2400
2026	0	32200	200800	0.01075	300	2200
2027	0	32200	200800	0.00960	300	1900
2028	0	32200	200800	0.00857	300	1700
2029	0	32200	200800	0.00765	200	1500
2030	0	32200	200800	0.00683	200	1400
2031	0	32200	200800	0.00610	200	1200
2032	0	32200	200800	0.00544	200	1100
2033	0	32200	200800	0.00486	200	1000
2034	0	32200	200800	0.00434	100	900
2035	0	32200	200800	0.00388	100	800
				Totals	2460900	1382900

Benefit/Cost Ratio = 1382900/2460900 = .56

* Note:

OM&P Escalation Rate = 8 % for years 1 - 10
OM&P Escalation Rate = 0 % for years 11 - 50

Power Revenue Escalation Rate = 10 % for years 1 - 10
Power Revenue Escalation Rate = 0 % for years 11 - 50

Discount Rate = 12 % for years 1 - 50

TABLE III-5

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF ECONOMIC FEATURES
NEVADA CREEK HYDROELECTRIC PROJECT

Interest Rate:	12%
Total Project Cost:[1/]	$1,989,000
Annual Debt Service:	243,300
Annual Operation and Maintenance:	16,100
Total Annual Cost:	259,400
Production Cost, Mills/kWh:	201.1
Production Cost, $/kW:	3,978
Power Value, Mills/kWh:[2/]	66
Benefit/Cost Ratio:	0.56

1/ July 1984.

2/ July 1986.

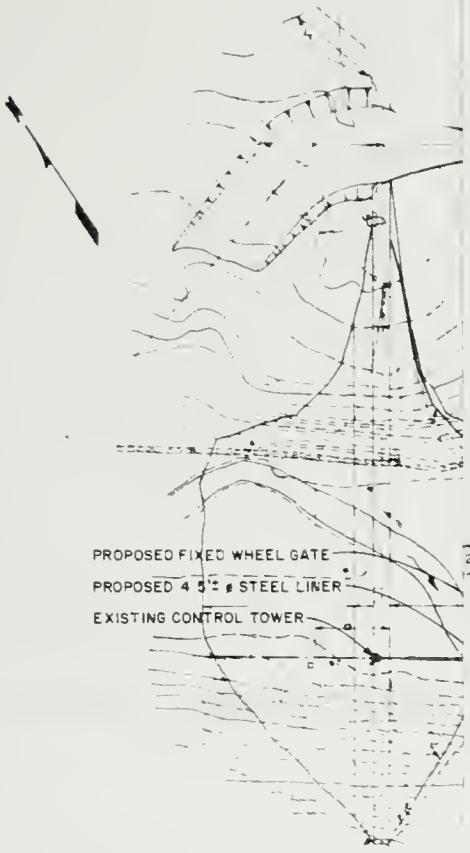
TABLE III-6

MONTANA HYDROELECTRIC RECONNAISSANCE
DISSOLVED OXYGEN AND
TEMPERATURE STANDARDS
NEVADA CREEK HYDROELECTRIC PROJECT

Parameter	Standard
Dissolved Oxygen	• Cannot fall below 7 mg/l.
Temperature	• No more than 1 degree increase when the water temperature is 32 to 36° F.
	• Cannot exceed 67° F when the water temperature is 66 to 66.5° F.
	• No more than a 0.5 degree increase when the water temperature is above 66.5° F.
	• No more than a 2 degree decrease per hour when the water temperature is above 55 F.
	• Cannot decrease more than 2 degrees when the water temperature is 55 to 32° F.

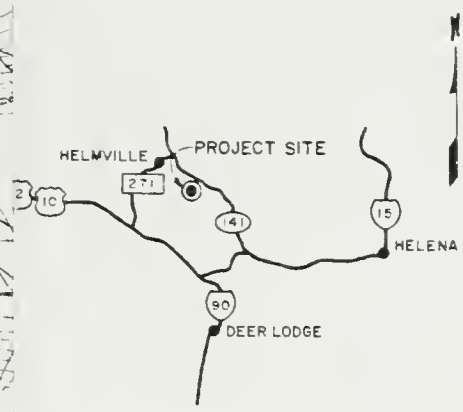
Source: Horpestad, pers. commun., 1982.

SFNBI-487-989-I

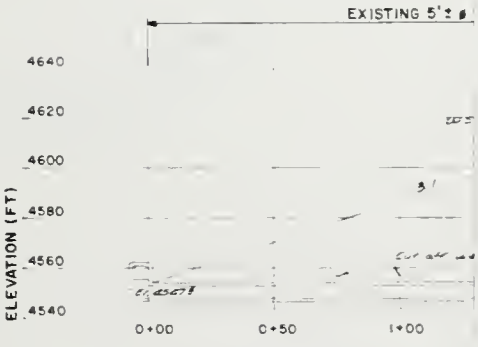


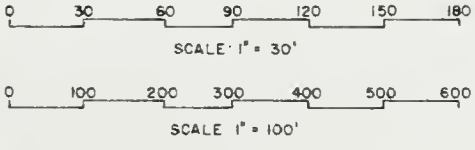
GENERAL
SCALE 1" = 10

LOCATION MAP



VICINITY MAP





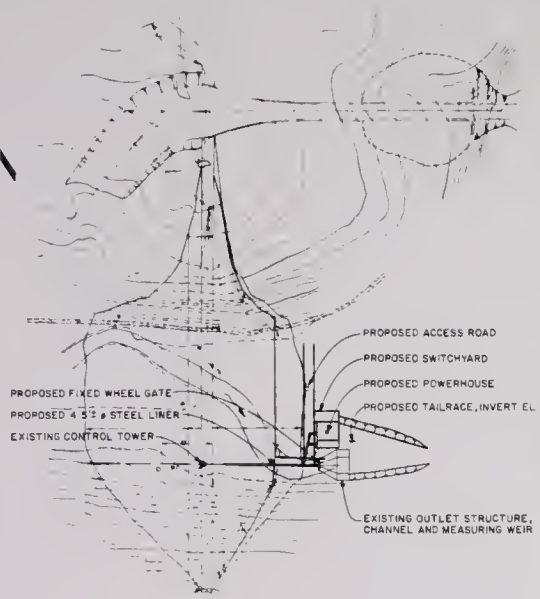
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

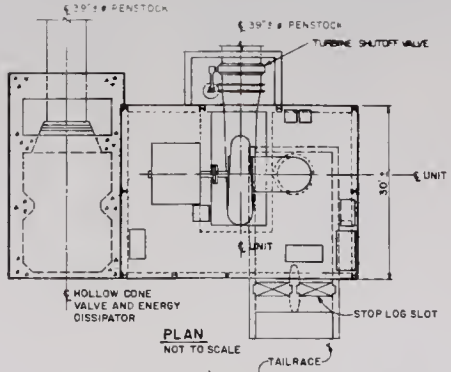
NEVADA CREEK HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

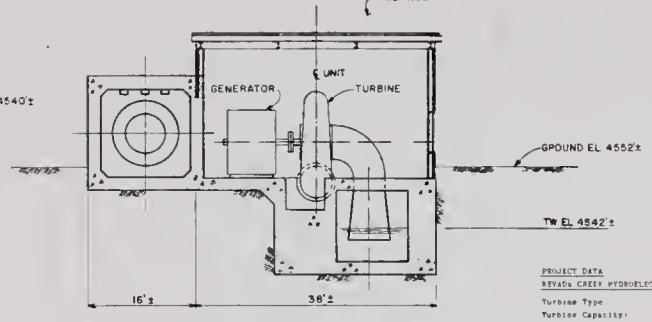
FIGURE III-1



GENERAL PLAN
SCALE 1" = 100'

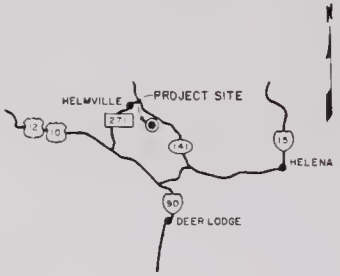


PLAN
NOT TO SCALE



SECTION ALONG CENTERLINE OF POWERHOUSE
NOT TO SCALE

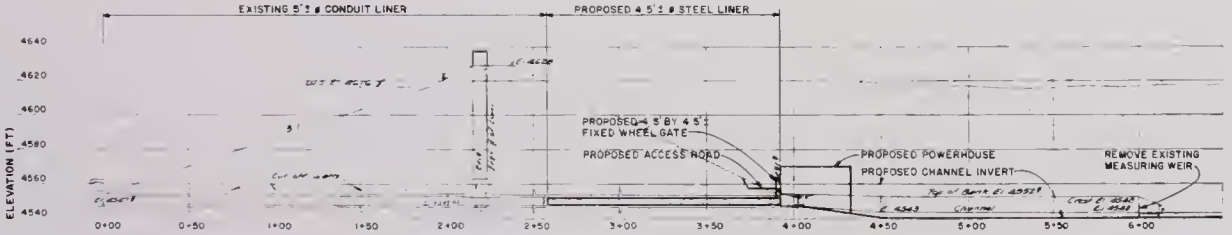
LOCATION MAP



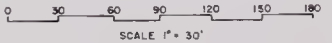
VICINITY MAP

PROJECT DATA
NEVADA CREEK HYDROELECTRIC PROJECT

Turbine Type	Horizontal Francis
Turbine Capacity:	500 kW (one unit)
Rated Head	66 ft
Rated Flow	100 cfs
Average Annual Energy:	1.3 GWh



PROFILE
SCALE 1" = 30'



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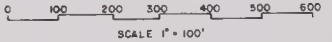


SCALE 1" = 100'

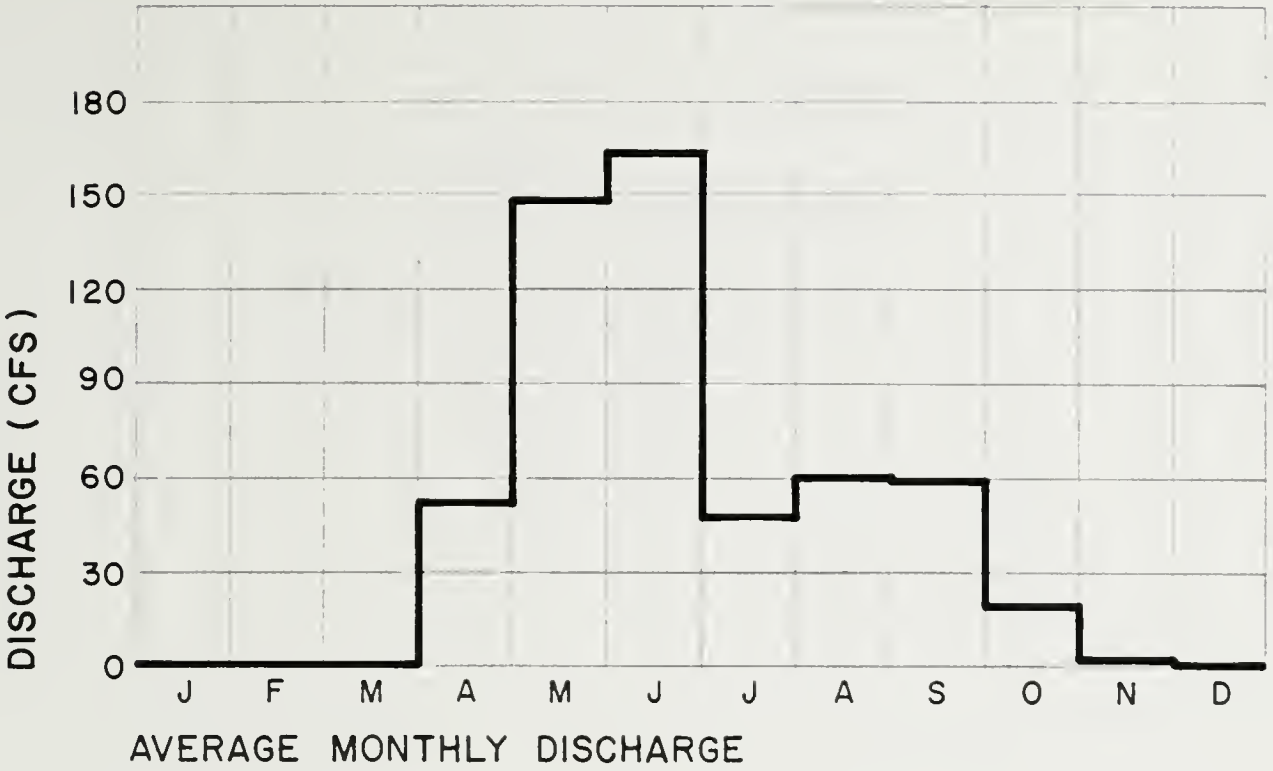
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

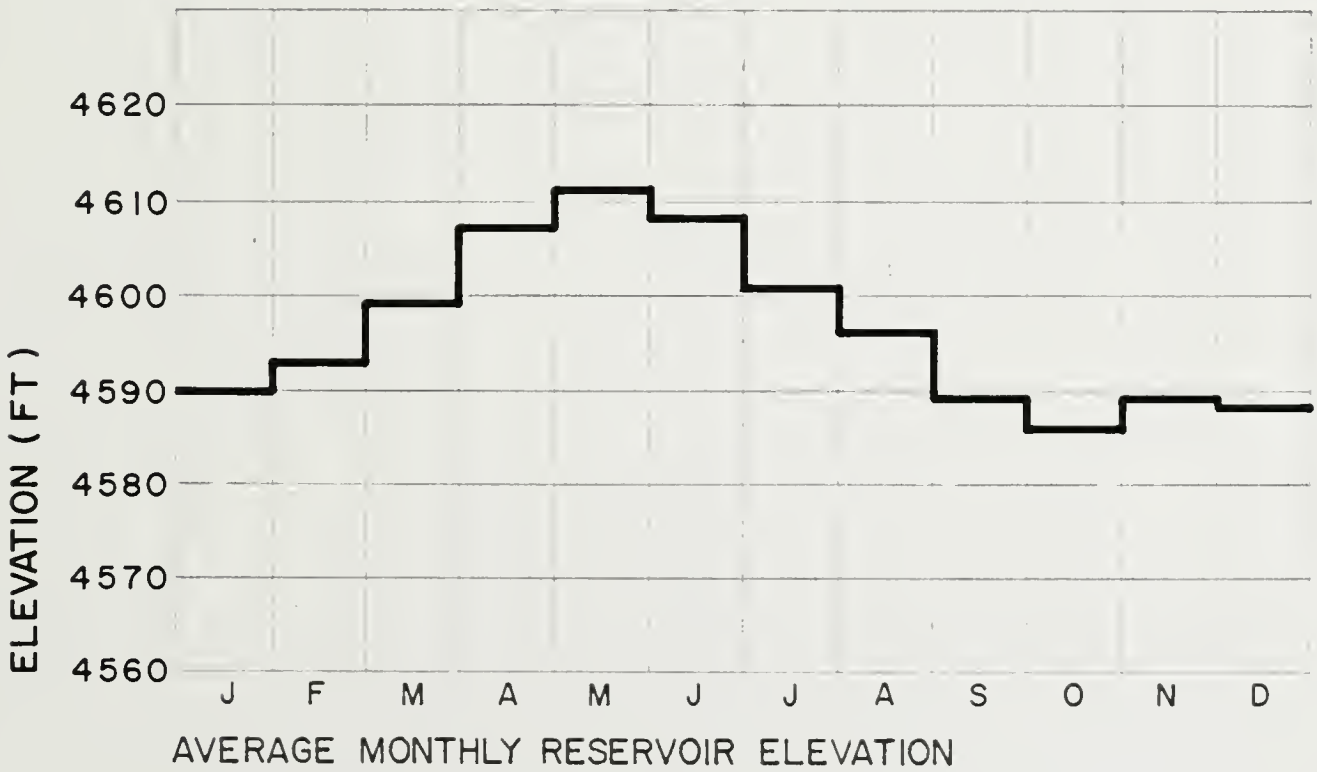
MONTANA HYDROELECTRIC RECONNAISSANCE

NEVADA CREEK HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

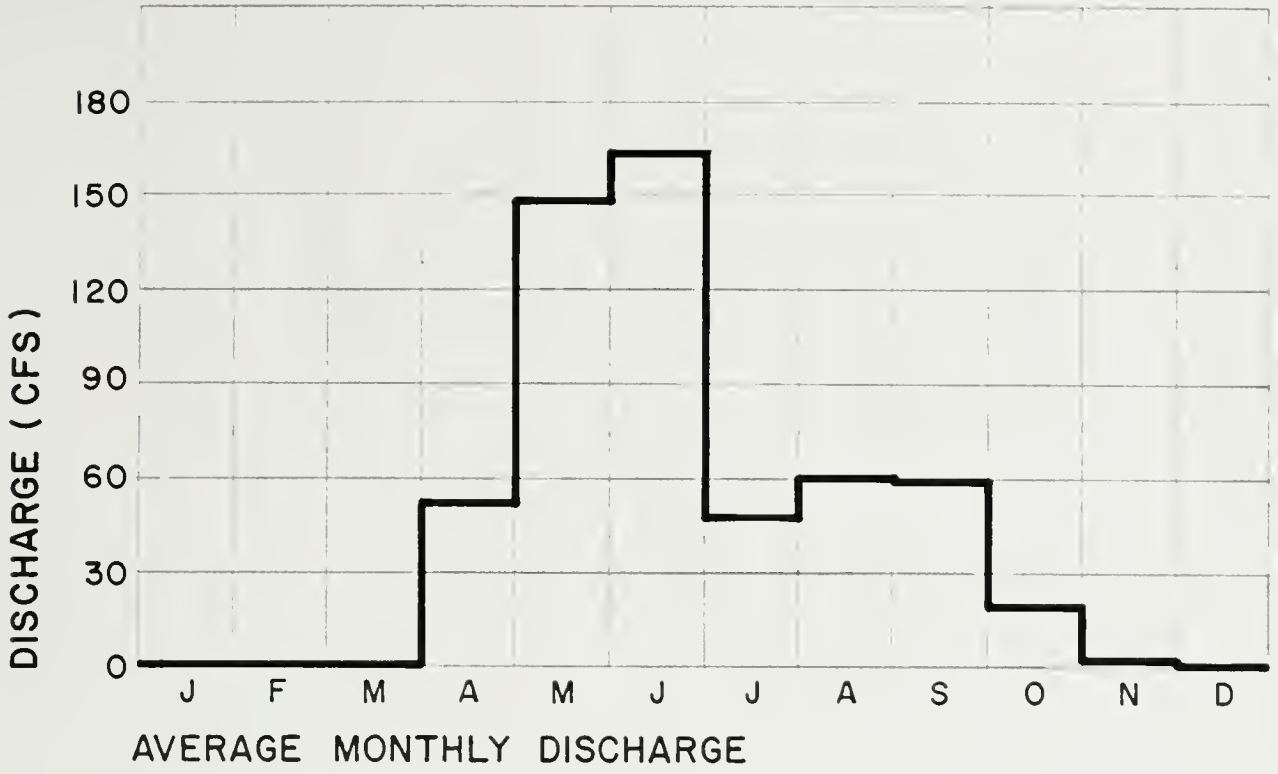
FIGURE III-1

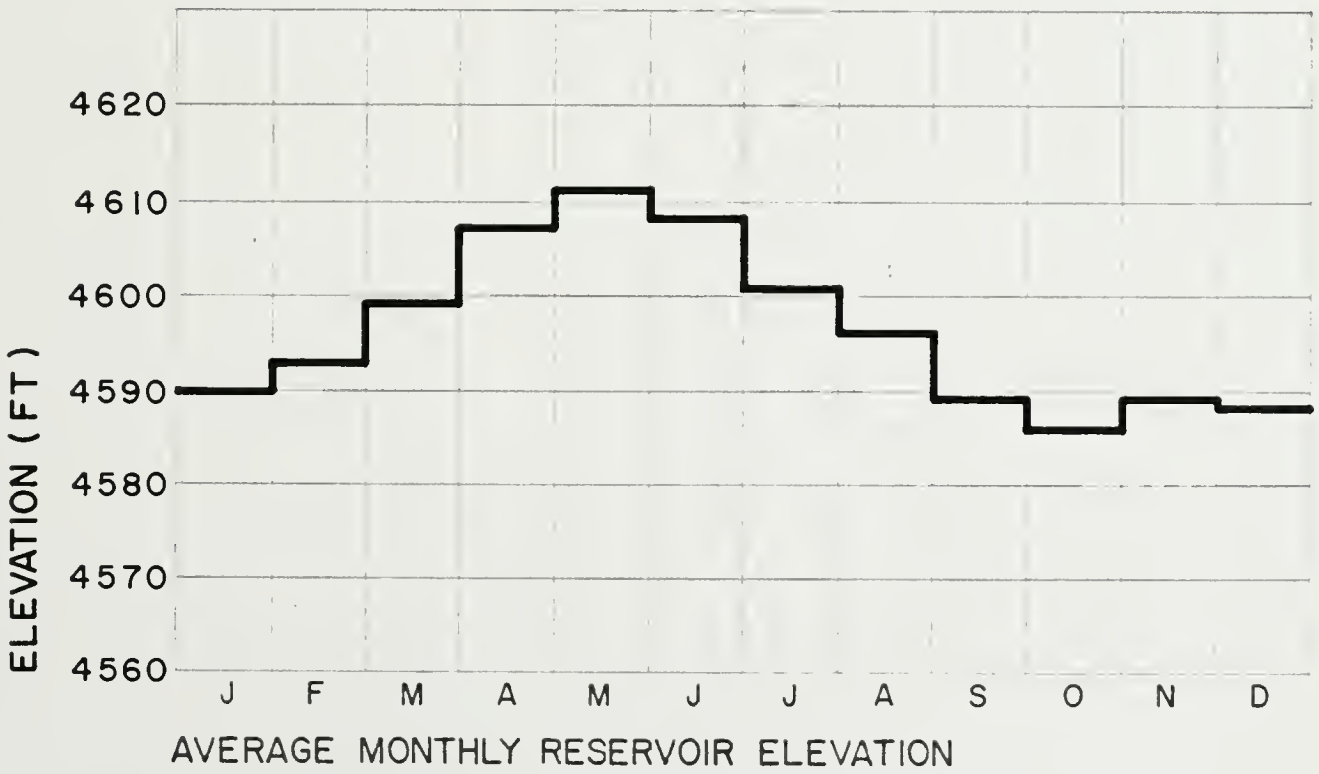




STATE OF MONTANA
MONTANA HYDROELECTRIC RECONNAISSANCE
NEVADA CREEK

FIGURE
III-2





STATE OF MONTANA
MONTANA HYDROELECTRIC RECONNAISSANCE
NEVADA CREEK

FIGURE
III-2

RUBY DAM AND RESERVOIR

RUBY DAM OUTLET WORKS

SECTION IV

RUBY DAM HYDROELECTRIC PROJECT

A. GENERAL

The Ruby Dam Hydroelectric Project would be located at the Ruby Dam, an earthfill structure on the Ruby River approximately six miles south of Alder. The dam is in Madison County. The reservoir impounded by the dam is used primarily for irrigation storage. The proposed project would utilize flow releases through the dam outlet works to produce approximately 9.5 million kilowatt-hours of electrical energy annually.

B. EXISTING FACILITIES

The main features of the Ruby River Project are the dam, reservoir, spillway, and outlet works. Additional existing features significant to the development of a hydroelectric project include access to the site and the existence of electrical transmission lines. The existing facilities are described in more detail below. The arrangement of the facilities is shown on Figure IV-1.

1. Dam

Ruby Dam is a zoned earthfill embankment with a maximum height of 111 feet and a crest length of 846 feet at elevation 5,410 feet. The dam has a crest width of 25 feet and was placed on slopes of 2:1.

The spillway is located at the right abutment of the dam (looking downstream). The spillway drops about 103 feet over a distance of about 361 feet. The spillway crest elevation is 5,392 feet. The spillway is 125 feet wide at the crest and

tapers to about 75 feet in width at the stilling basin. The Dam Safety Report (1980) indicates that the spillway capacity is seriously inadequate.

The outlet works intake is on the left abutment just upstream from the dam. An approach channel at elevation 5,300 feet delivers flow from the bottom of the reservoir to an intake structure. The flow is discharged through an eight foot diameter horseshoe tunnel. The total length of the tunnel is about 630 feet; of this total, 415 feet are upstream from the outlet control gates and are pressurized, and 215 feet are downstream from the control gates and operate under open channel flow conditions. The tunnel discharges to a stilling basin at elevation 5,298.

The description presented above reflects the existing conditions at the dam. For purposes of this report, no attempt has been made to determine the effects of modification of the facilities in response to the Dam Safety Report.

2. Site Access

A paved road passes the immediate vicinity of the project on the right bank. Access for construction of the powerhouse site would be by fording the river just downstream from the dam. Permanent access to the powerhouse site would be from an existing jeep trail using a bridge downstream from the dam.

3. Transmission Lines

During the June 4, 1982 field trip to the Ruby Dam site, transmission lines were observed in the immediate vicinity of the proposed powerhouse location. It is anticipated that transmission lines with adequate capacity for the transmission of power from the Ruby Dam Project exist in the immediate area of the project. The project is in the Montana Power Company

service area. The area is also served by the Vigilante Electric Co-op. A major Montana Power Company transmission line passes within two miles of the project. For purposes of estimating the project cost, it has been assumed that it will be necessary to construct approximately two miles of new transmission lines. The exact location and nature of the interconnection to the existing power grid would need to be determined as part of a detailed feasibility study. Costs associated with transmission lines could include construction of new lines or reconductoring of existing lines. The limited data obtained during this study were not adequate to make this determination.

C. PROPOSED PROJECT

A conceptual level layout of the Ruby Dam Hydroelectric Project was prepared for purposes of demonstrating the overall technical and economic feasibility of the project. No attempt was made to optimize the project configuration. Additional configurations should be considered as part of a detailed feasibility study.

1. Project Description

The Ruby River Hydroelectric Project would consist of a powerhouse containing two horizontal Francis turbines at the downstream end of the existing outlet works. One of the turbines would have a capcity of 2,800 kW and the other would have a capacity of 950 kW; the turbine selection is discussed below under the heading "Power Study".

The proposed layout is presented as Figure IV-1. The outlet works tunnel downstream from the control gates would be lined with an 84-inch diameter steel liner and the space between the tunnel and liner would be filled with grout. The liner would bifurcate downstream from the tunnel outlet; a fixed wheel gate

would be provided at the bottom end of the tunnel for passing flood flows. The reduction in outlet capacity would be minimal. The existing sharp crested weir downstream from the outlet would be replaced by a lower weir and the channel excavated from the weir to the powerhouse to provide an additional eight feet of head. The powerhouse would be equipped with a synchronous bypass valve that would open in the event of a turbine shutdown. The switchyard would be located adjacent to the powerhouse and would contain the main power transformer, line disconnect switch, oil circuit breaker, revenue metering apparatus and other switching equipment.

2. Hydrology and Hydraulics

Ruby River is a tributary of the Jefferson River, which is part of the Missouri River system. Ruby River Reservoir is located in Madison County, about six miles south of Alder, MT. The stored water is used for irrigation and recreation purposes. The U.S. Geological Suervey (USGS) maintains a stream gage on the river 0.2 miles downstream of the reservoir, and the Montana Department of Natural Resources and Conservation (DNRC) maintains a reservoir level gage at the site.

The discharge downstream from the dam is recorded by USGS stream gage 06020600, "Ruby River below Reservoir, near Alder, MT." The total drainage area above the site is 596 square miles, and the altitude of the streamgage is 5,290 feet NGVD. Published flow records are available from November 1962 to the current year. The maximum and minimum discharges over the period of record were 1,610 cfs on June 10, 1970, and 19 cfs on February 15-19, 1967. The average discharge over the 15 years of record (1962 to 1978) was 161,600 acre-feet per year, which is equal to an average annual discharge of about 223 cfs.

The water surface level in the reservoir is recorded by DNRC gage 41C01900, "Ruby River by Reservoir." Records have been maintained for this reservoir since July 1938, with several years of incomplete records occuring in 1951 to 1960. Continuous records have been kept since 1960. The maximum observed reservoir contents was 46,040 AF in August, 1975, and no storage was observed in 1938, 1955 and 1961. The total usable storage available in the reservoir is 38,950 AF between the bottom of the outlet elevation 5,300 feet, and the spillway crest elevation 5,392 feet. The dead storage, below elevation 5,300 feet, is 100 AF.

The existing water surface elevation downstream from the outlet works varies from 5,302.5 feet at zero discharge to about elevation 5,308 at 1,600 cfs. As previously mentioned, the existing measuring weir would be replaced by a weir with a lower crest elevation as part of this project. The downstream water surface elevation would be lowered by about six feet after this modification.

For purposes of estimating installed capacities, power production and energy production, the historical records of flows and reservoir elevations for the years 1964 through 1973 were used to develop an annual hydrograph of average monthly flows, and an average monthly record of water surface elevations. These values are shown graphically on Figure IV-2. The average annual flow for this period of time was 220 cfs. This figure is within two percent of the long-term average of 223 cfs and indicates that the hydrograph selected for the study is representative of the long-term average.

3. Power Study

The average annual hydrograph and average record of monthly water surface elevations described above were used to estimate the installed capacity and annual average energy production for

the Ruby Dam Project. This determination was made based on typical turbine performance characteristics and the physical characteristics of the site. The head available for power production was estimated as the difference between the headwater and tailwater elevation minus an allowance for head losses. The capacity of the plant was not optimized; however, an attempt was made to select the turbine so that its operation would encompass a wide variation of head and flow.

The flow pattern at Ruby Dam varies seasonally, with a low, steady flow year round and high flows during the spring and ensuing irrigation season. For this site, a two-unit turbine installation was selected. One unit would be a small horizontal Francis turbine that would operate almost continuously, while the other would be a larger, horizontal Francis turbine that would operate primarily during the irrigation season. The large unit would have a rated head of 87 feet, rated flow of 450 cfs, and installed capacity of 2,800 kW. The small turbine would have a rated head of 87 feet, rated flow of 150 cfs, and installed capacity of 950 kW. The physical features of the Ruby River Hydroelectric Project are summarized on Table IV-1 and are shown graphically on Figure IV-1.

4. Cost Estimate

The total project capital cost consists of the direct construction cost; the associated indirect costs for engineering, management and administration; and interest during construction. The cost estimate for the Ruby River Project is presented as Table IV-2. This cost estimate is based on bid prices for similar construction work, recent manufacturers quotes for mechanical and electrical equipment, and experience with other projects. The estimate also includes allowances for contingencies and for the costs of engineering. The contingency allowance is 15 percent of the mechanical and electrical

costs plus 20 percent of all other costs. The engineering costs cover activities which include detailed feasibility studies, obtaining miscellaneous licenses and permits, final design, contract plans and specifications, and engineering services during construction. This amount was estimated as 25 percent of the direct construction cost plus contingencies. An allowance was also made for owner administration, financial, and legal expenses. Interest during construction was based on an 18-month construction period and 12 percent interest. No allowance was made for interest income on retained funds and the calculation of interest during construction is therefore conservative.

The cost estimate is presented at July 1982 price levels. The estimated total project capital cost for the Ruby Dam Project is $4,333,650. The cost would be $5,054,800 if escalated to the proposed bid date of July 1984 at eight percent annual inflation.

5. Economic Analysis

The benefits and costs associated with the Ruby Dam Hydroelectric Project were assessed in order to determine the overall economic feasibility of the project. The project capital cost was escalated to July, 1984, at eight percent annual interest; this is the proposed bid date for the project. The value of power was escalated at ten percent annual interest to January 1986, the proposed on-line date for the project. It was assumed that the project would be financed with bonds having a life of 35 years and bearing a 12 percent interest rate. The cost of operation and maintenance for the first year of operation would be 1.25 percent of the capital cost plus contingencies. The annual cost of the Ruby Dam Hydroelectric Project for the first year of operation (1986) is presented as Table IV-3.

It was assumed that the rate of general inflation is eight percent and that energy would escalate at ten percent annually. Inflation was considered for 10 years beyond the proposed on-line date of January 1986 and then held constant. All costs were discounted at 12 percent annual interest to January 1986 and the present worth of the benefits was compared to the present worth of costs to produce a benefit/cost (B/C) ratio for the project. The B/C calculation is presented as Table IV-4 and the economic features of the project are summarized on Table IV-5. The B/C ratio for this project is 1.63.

D. ENVIRONMENTAL OVERVIEW

1. Overview

Ruby Dam and reservoir is located on the Ruby River in the Missouri River Basin in south central Montana. It is situated on the western flank of the Rocky Mountains in a sagebrush-grassland area with pine and juniper at the higher elevations. The elevation of the ogee crest is 5,392 feet. The project is operated by the Ruby River Water Users Association for flood control and irrigation. Fishing is popular in the stream above and below the dam as well as in the reservoir.

The reservoir contains wild populations of rainbow and brown trout. In addition, the Department of Fish, Wildlife and Parks stocks the reservoir with Yellowstone cutthroat trout with the objective that the population will eventually replinish itself without stocking (Wells, pers. commun., 1982).

Sediment is the major water quality problem in the reservoir. Upstream from the reservoir, the river passes through an area of unstable geology and soils. The instability, coupled with poor land use practices, has caused

sediment to become a severe problem in the reservoir (Wells, pers. common., 1982). Otherwise, water quality has remained fairly high in the reservoir.

The Water Quality Bureau of the Montana Department of Health and Environmental Sciences has classified the Ruby River as B-1. The standards for dissolved oxygen and temperature for the classification are presented in Table IV-6.

The primary concern of the Department of Fish, Wildlife and Parks is the flow available in the Ruby River below the dam for maintaining fishery resources (Wells, pers. commun., 1982). The river supports a good population of rainbow and brown trout that is often limited by the flows in the river during winter months. During periods of drought, the reservoir is lowered drastically in summer months and, consequently, little flow is available for release during winter months. The Department of Fish, Wildlife and Parks has not negotiated any minimum flows for the river.

Ruby Reservoir is used as a resting place for Canada geese and ducks, especially during the migration seasons in spring and fall. Some geese and ducks have been observed nesting in the area as well (Well, pers. commun., 1982).

2. Potential Problems

The environmental characteristics of the site suggest that potential problems would be minimal. In this study, it was assumed that historical outflows would be maintained, the elevation of the intake for the outlet works would not change, and that most of the spilled flow would be diverted through the power plant. This latter change may cause a slight reduction in the concentration of dissolved oxygen in the discharge water, but should not affect the value of the fishery habitat below the dam. Temperature of the discharge water may differ

slightly from that of the receiving water, but should still meet the established water quality standards. Water levels in the reservoir and downstream should not vary from what has been experienced in the past.

Minimum streamflows may be required during construction and operation. Flows are already critically low during winter months and any further reduction would be unacceptable.

Data regarding water quality at the site are extremely limited. It is not known if dissolved oxygen drops below the 7 mg/l standard at times during the year. The Water Quality Bureau, however, might require the project to meet this standard in the Ruby River. Insufficient information is available to determine whether the project could meet this standard.

The transmission line is expected to be less than two-miles long and thus should have no major effect on fish or wildlife habitat. The area is rich in cultural resources, however, and a survey of the route may be required before an exemption application can be filed.

3. Recommended Action

a. Dissolved Oxygen and Minimum Streamflows. The DNRC should collect data regarding dissolved oxygen concentrations in the reservoir and the release waters at different flow conditions to define whether a potential problem exists. The DNRC should also enter into discussions with the Water Quality Bureau to determine what standards may be required for the discharge waters at the power plant. The DNRC should consult with the Department of Fish, Wildlife and Parks to agree on minimum flows during construction of the project.

b. Archeologic Survey. The DNRC should consult with the State Historic Preservation Officer to determine if an archeologic survey is warranted or required for the transmission line corridor. The survey should be conducted to identify any cultural or historical resources along the route and to determine what mitigation measures might be desireable.

E. CONCLUSIONS AND RECOMMENDATIONS

The Ruby River Hydroelectric Project is a technically and economically feasible project. The project would have a negative cash flow for the first year of operation if it was to come on-line in 1986. It is recommended that the project be developed before 1990.

TABLE IV-1

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF PHYSICAL FEATURES
RUBY DAM HYDROELECTRIC PROJECT

Turbine Type:	Horizontal Francis
Turbine Capacity:	2,800 kW 950 kW
Rated Head:	87 ft
Rated Flow:	450 cfs 150 cfs
Average Annual Energy:	9.5 GWh

TABLE IV-2

MONTANA HYDROELECTRIC RECONNAISSANCE
PROJECT CAPITAL COSTS

RUBY DAM HYDROELECTRIC PROJECT

	Item	Cost
1.	Structues and Improvements	$ 472,150
2.	Reservoirs, Dams, and Waterways	458,000
3.	Turbines and Generators	895,000
4.	Accessory Electrical Equipment	400,000
5.	Miscellaneous Mechanical Equipment	25,000
6.	Switchyard	80,000
7.	Transmission Lines	60,000
	Direct Construction Cost	2,390,150
	Contingencies	408,000
	Subtotal	2,798,150
	Engineering (25%)	699,500
	Subtotal	3,497,650
	Administrative, Legal, and Financial (5%)	174,900
	Subtotal	3,672,550
	Interest During Construction	661,100
	TOTAL PROJECT CAPITAL COST (July 1, 1982)	4,333,650
	TOTAL PROJECT CAPITAL COST (Escalated to July 1984 at 8% compounded annually)	$5,054,800

TABLE IV-3

ESTIMATED ANNUAL COST
MONTANA HYDROELECTRIC RECONNAISSANCE

RUBY RIVER HYDROELECTRIC PROJECT

1.	Total Project Capital Cost escalated to July, 1984	$5,054,800
2.	Estimted Cost of Capital: 12%	
3.	Economic Life of Project 50 years	
4.	Annual Costs	
	4.1 Amortization 1/	618,200
	4.2 O, M & R 2/	40,800
		659,000
5.	Estimated Average Annual Generation	
	9,480,000	
6.	Unit Cost of Power 3/	
	$\frac{\$\ 659,000}{9,480,000} \times 1000 = 69.5$ mills/kWh	

1/ Amortized for 35 years at 12%.
2/ 1.25% of capital cost plus contingency, escalated to July 1984 at 8% annual inflation.
3/ First year of operation (1986).

TABLE IV-4

Benefit/Cost Analysis - Tudor Engineering Company

RUBY RIVER HYDROELECTRIC PROJECT - STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

JULY 1982

Year	Cost Streams		Benefit Stream (*)	Present Worth Factor (*)	Present Worths	
	Debt Service	OM&R (*)			Cost	Benefit
1986	618200	40800	625700	1.00000	659000	625700
1987	618200	44100	688200	0.89286	591300	614500
1988	618200	47600	757100	0.79719	530800	603500
1989	618200	51400	832800	0.71178	476600	592800
1990	618200	55500	916100	0.63552	428200	582200
1991	618200	59900	1007700	0.56743	384800	571800
1992	618200	64700	1108400	0.50663	346000	561600
1993	618200	69900	1219300	0.45235	311300	551500
1994	618200	75500	1341200	0.40388	280200	541700
1995	618200	81600	1475300	0.36061	252300	532000
1996	618200	81600	1475300	0.32197	225300	475000
1997	618200	81600	1475300	0.28748	201200	424100
1998	618200	81600	1475300	0.25668	179600	378700
1999	618200	81600	1475300	0.22917	160400	338100
2000	618200	81600	1475300	0.20462	143200	301900
2001	618200	81600	1475300	0.18270	127800	269500
2002	618200	81600	1475300	0.16312	114100	240700
2003	618200	81600	1475300	0.14564	101900	214900
2004	618200	81600	1475300	0.13004	91000	191900
2005	618200	81600	1475300	0.11611	81200	171300
2006	618200	81600	1475300	0.10367	72500	152900
2007	618200	81600	1475300	0.09256	64800	136600
2008	618200	81600	1475300	0.08264	57800	121900
2009	618200	81600	1475300	0.07379	51600	108900
2010	618200	81600	1475300	0.06588	46100	97200
2011	618200	81600	1475300	0.05882	41200	86800
2012	618200	81600	1475300	0.05252	36800	77500
2013	618200	81600	1475300	0.04689	32800	69200
2014	618200	81600	1475300	0.04187	29300	61800
2015	618200	81600	1475300	0.03738	26200	55200
2016	618200	81600	1475300	0.03338	23400	49200
2017	618200	81600	1475300	0.02980	20900	44000
2018	618200	81600	1475300	0.02661	18600	39300
2019	618200	81600	1475300	0.02376	16600	35100
2020	618200	81600	1475300	0.02121	14800	31300
2021	0	81600	1475300	0.01894	1500	27900
2022	0	81600	1475300	0.01691	1400	24900
2023	0	81600	1475300	0.01510	1200	22300
2024	0	81600	1475300	0.01348	1100	19900
2025	0	81600	1475300	0.01204	1000	17800
2026	0	81600	1475300	0.01075	900	15900
2027	0	81600	1475300	0.00960	800	14200
2028	0	81600	1475300	0.00857	700	12600
2029	0	81600	1475300	0.00765	600	11300
2030	0	81600	1475300	0.00683	600	10100
2031	0	81600	1475300	0.00610	500	9000
2032	0	81600	1475300	0.00544	400	8000
2033	0	81600	1475300	0.00486	400	7200
2034	0	81600	1475300	0.00434	400	6400
2035	0	81600	1475300	0.00388	300	5700
				Totals	6251300	10163000

Benefit/Cost Ratio = 10163000/6251300 = 1.63

* Note:

OM&R Escalation Rate = 8 % for years 1 - 10
OM&R Escalation Rate = 0 % for years 11 - 50

Power Revenue Escalation Rate = 10 % for years 1 - 10
Power Revenue Escalation Rate = 0 % for years 11 - 50

Discount Rate = 12 % for years 1 - 50

TABLE IV-5

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF ECONOMIC FEATURES
RUBY DAM

Interest Rate:	12%
Total Project Cost: 1/	5,054,800
Annual Debt Service:	618,200
Annual Operation and Maintenance:	40,800
Total Annual Cost:	659,000
Production Cost, Mills/kWh:	69.5
Production Cost, $/kW:	1,348
Power Value, Mills/kWh: 2/	66
Benefit/Cost Ratio:	1.63

1/ July 1984.

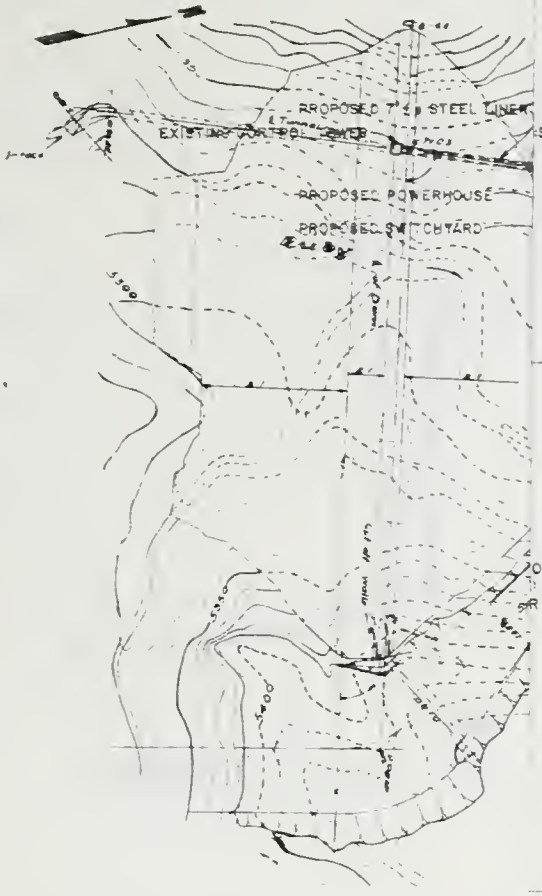
2/ July 1986.

TABLE IV-6

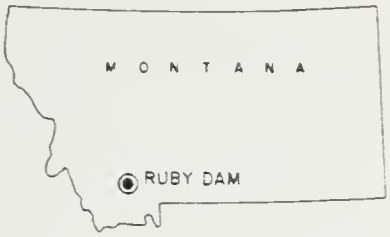
MONTANA HYDROELECTRIC RECONNAISSANCE
DISSOLVED OXYGEN AND
TEMPERATURE STANDARDS
RUBY DAM HYDROELECTRIC PROJECT

Parameter	Standard
Dissolved Oxygen	• Cannot fall below 7 mg/l.
Temperature	• No more than 1 degree increase when the water temperature is 32 to 36° F.
	• Cannot exceed 67° F when the water temperature is 66 to 66.5° F.
	• No more than a 0.5 degree increase when the water temperature is above 66.5° F.
	• No more than a 2 degree decrease per hour when the water temperature is above 55 F.
	• Cannot decrease more than 2 degrees when the water temperature is 55 to 32° F.

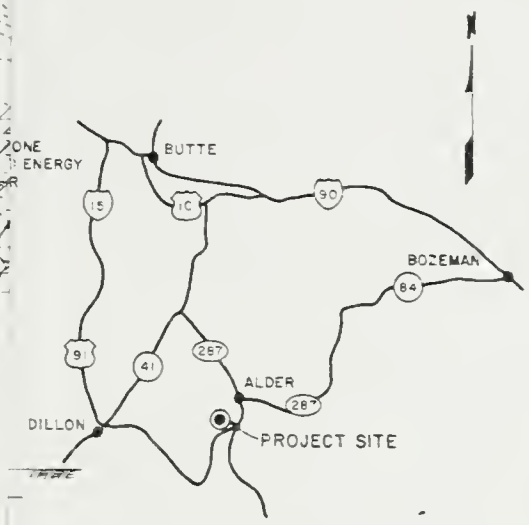
Source: Horpestad, pers. commun., 1982.



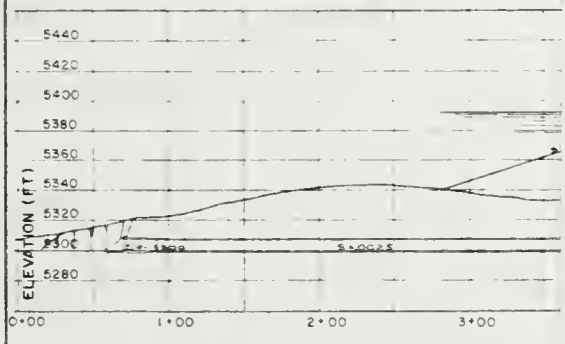
GENERAL PLAN
SCALE 1" = 100'

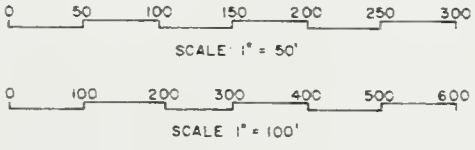


LOCATION MAP



VICINITY MAP





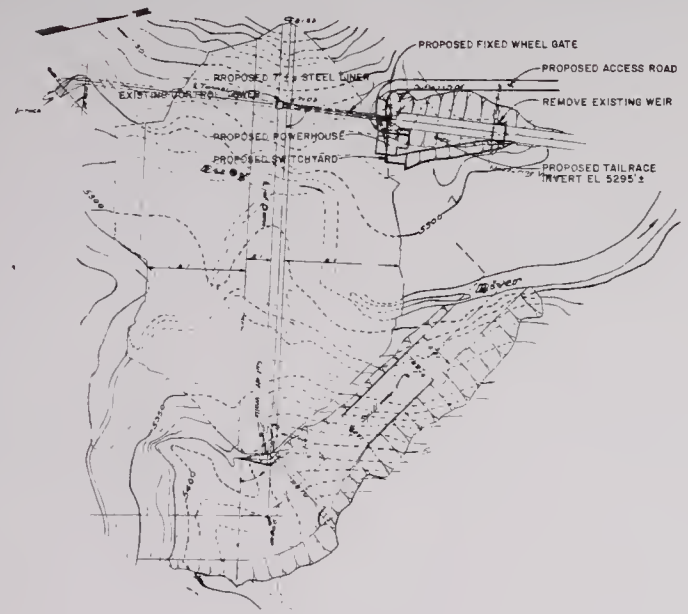
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

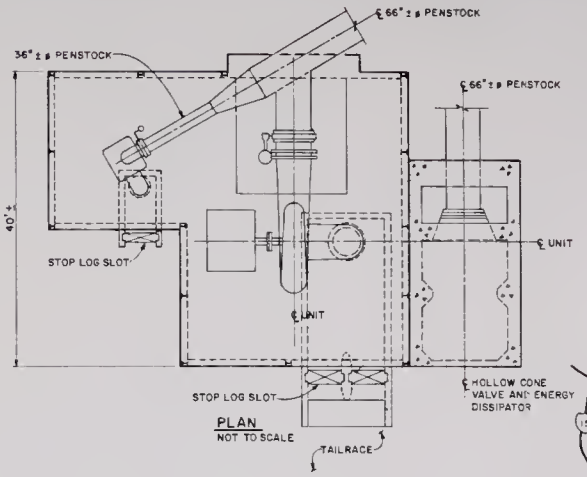
RUBY DAM HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

FIGURE IV-1

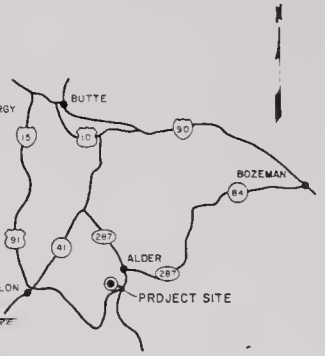


GENERAL PLAN
SCALE 1" = 100'

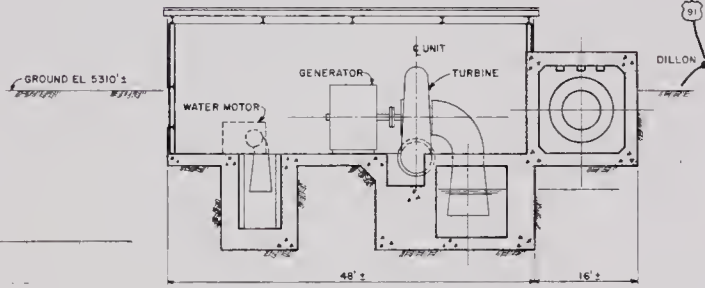


PLAN
NOT TO SCALE

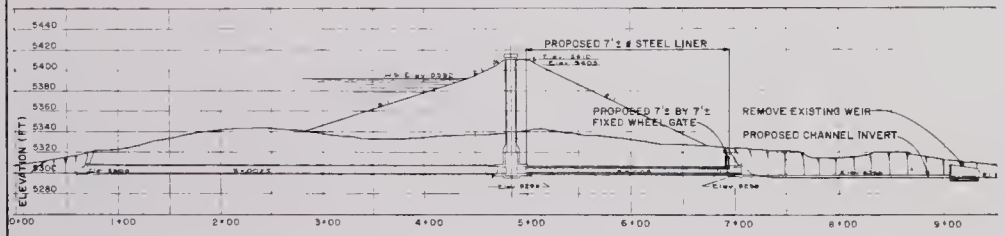
LOCATION MAP



VICINITY MAP



SECTION ALONG CENTERLINE OF POWERHOUSE
NOT TO SCALE



PROFILE
SCALE 1" = 50'

PROJECT DATA
RUBY DAM HYDROELECTRIC PROJECT

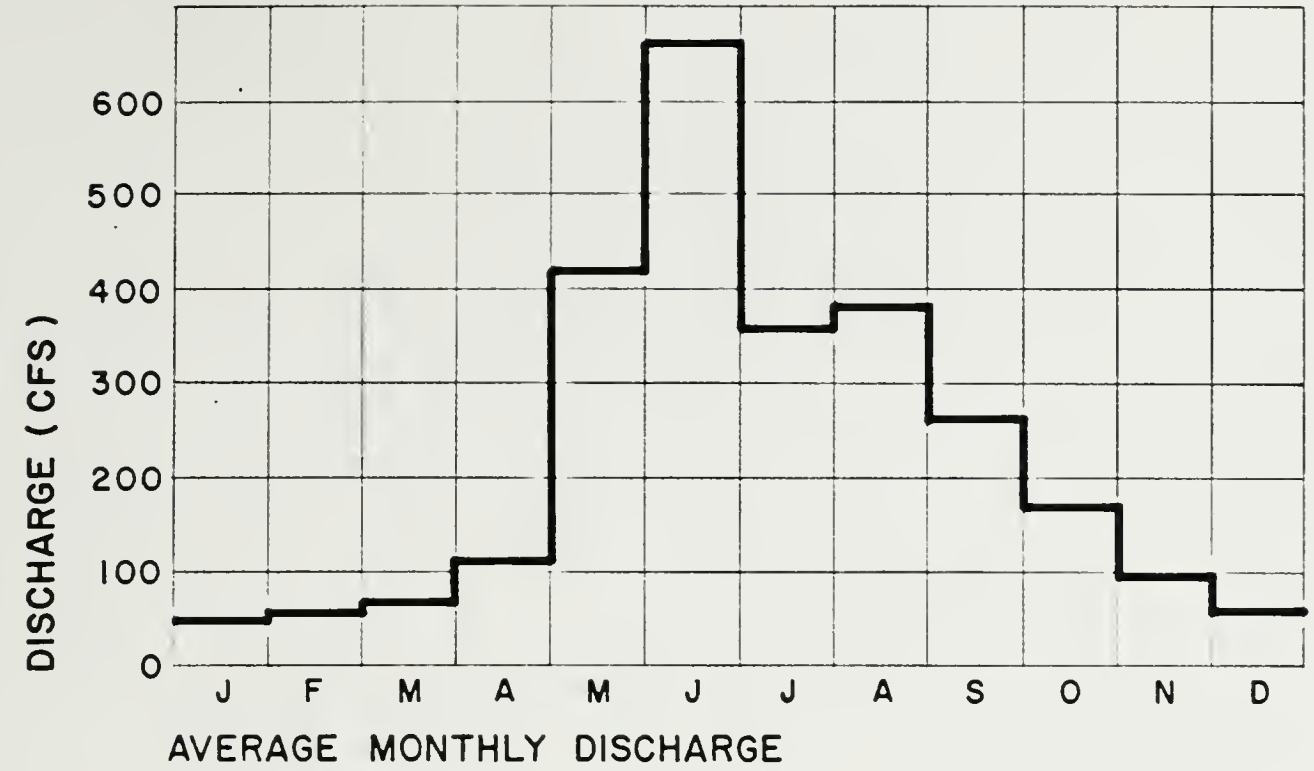
Turbine Type:	Horizontal Francis
Turbine Capacity	2,800 kW
	950 kW
Rated Head:	87 ft
Rated Flow:	450 cfs
	150 cfs
Average Annual Energy	8.5 GWh

0 50 100 150 200 250 300
SCALE 1" = 50'

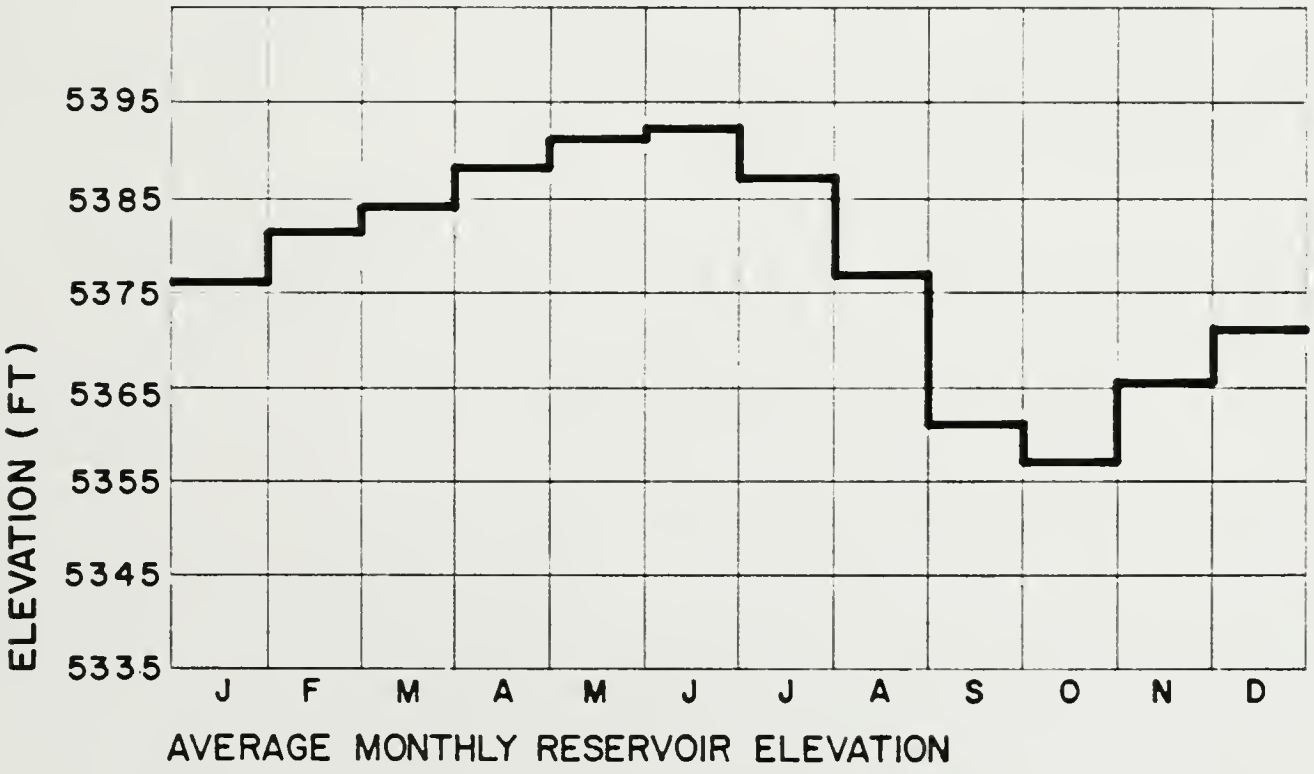
0 100 200 300 400 500 600
SCALE 1" = 100'

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA
MONTANA HYDROELECTRIC RECONNAISSANCE
RUBY DAM HYDROELECTRIC PROJECT
TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

FIGURE IV-1



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

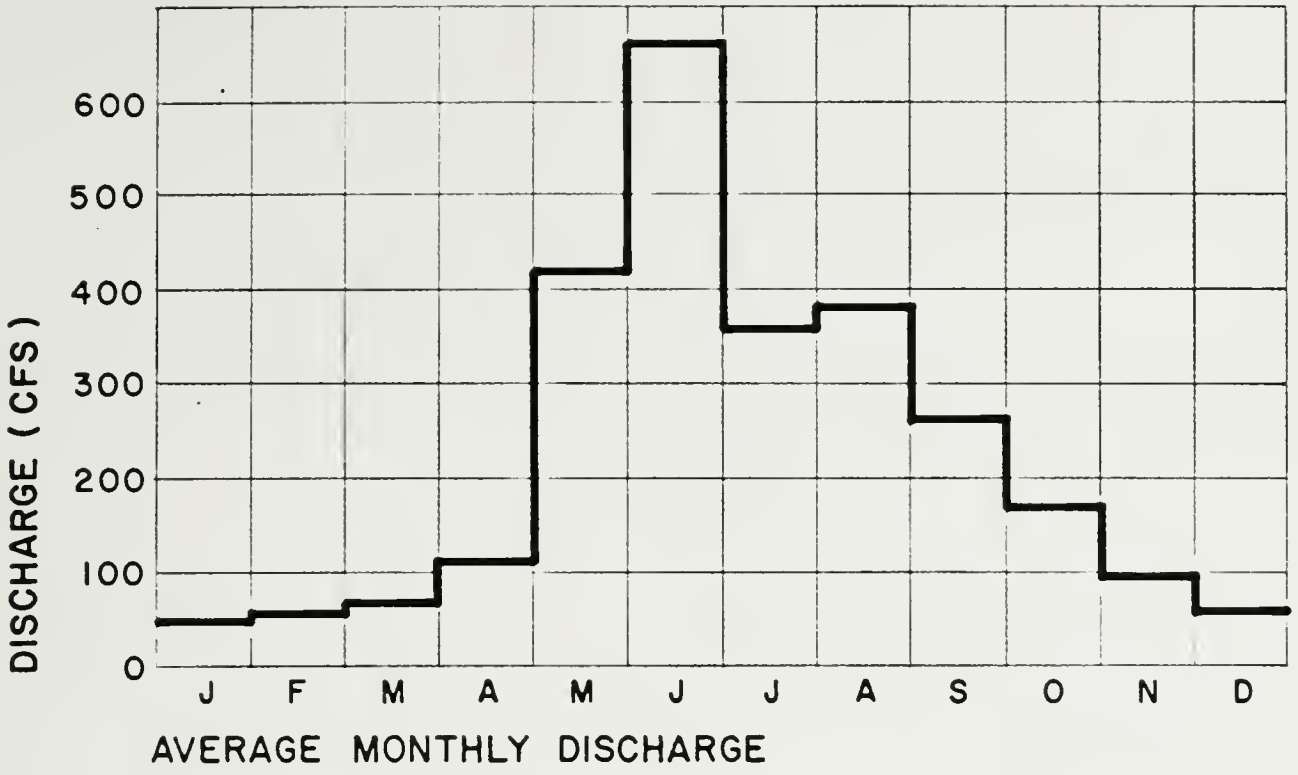
STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

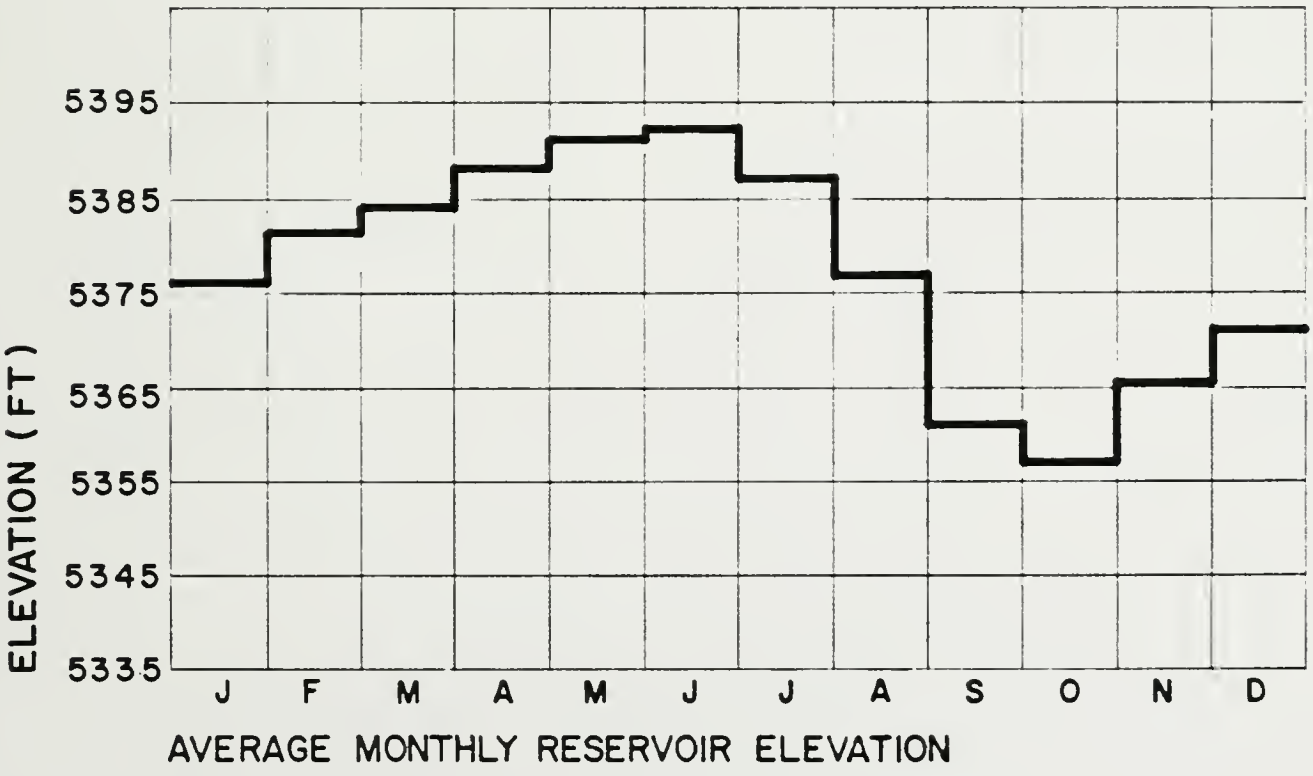
RUBY DAM

FIGURE

IV-2



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

RUBY DAM

FIGURE

IV-2

MIDDLE CREEK DAM AND RESERVOIR

MIDDLE CREEK DAM OUTLET WORKS

SECTION V
MIDDLE CREEK HYDROELECTRIC PROJECT

A. GENERAL

The Middle Creek Hydroelectric Project would be located at the Middle Creek Dam, an earthfill structure on Middle Creek approximately fifteen miles south of Bozeman, Montana. The dam and stream are also known as Hyalite Dam and Creek. The dam is in Gallatin County. The reservoir impounded by the dam is used primarily to supply irrigation water to 16,000 acres in the Gallatin Valley. The project also supplies municipal water for the City of Bozeman and Montana State University. The proposed project would utilize flow releases through the dam outlet works to produce approximately 3.3 million kilowatt-hours of electrical energy annually.

B. EXISTING FACILITIES

The main features of the Middle Creek Project are the dam, reservoir, spillway, and outlet works. Additional existing features significant to the development of a hydroelectric project include access to the site and the existence of electrical transmission lines. The existing facilities are described in more detail below. The arrangement of the facilities is shown on Figure V-1.

1. Dam

Middle Creek Dam is a zoned earthfill embankment with a maximum height of 106 feet and a crest length of 1,300 feet at elevation 6,709.2 feet. The dam has a crest width of 40 feet and was placed with slopes varying from 2:1 to 4:1. The Dam Safety Report (1980) indicates extensive seepage through the left abutment of the dam.

The spillway is located at the right abutment of the dam (looking downstream). The spillway crest elevation is 6,698.75 feet. The spillway is 40 feet wide at the crest. The Dam Safety Report indicates that the spillway concrete is badly deteriorated, and the reservoir is currently operated to minimize spillway use. The spillway does not have adequate capacity to pass the probable maximum flood.

The outlet works intake is near the center of the embankment, just upstream from the dam. Flow from the bottom of the reservoir enters a box type intake structure with trash racks with invert elevation 6,589. The flow is discharged through a five foot diameter conduit. The total length of the tunnel is about 610 feet; of this total, 250 feet are upstream from the outlet control gates and are pressurized, and 360 feet are downstream from the control gates and operate under open channel flow conditions. Over 220 feet of this downstream conduit is steel lined. The tunnel discharges to the stilling basin at the toe of the dam at elevation 6,582.

The description presented above reflects the existing conditions at the dam. For purposes of this report, no attempt has been made to determine the effects of modification of the facilities in response to the Dam Safety Report.

2. Site Access

An existing dirt road currently provide access to the crest of the dam. A short road from this road to the powerhouse site would be constructed. These roads would provide adequate access to the powerhouse location for construction, operation, and maintenance of the project.

3. Transmission Lines

A 500 kVA transmission line belonging to the Montana Power Company (MPC) passes about 15 miles from the proposed project site. No other transmission lines were observed in the area. For purposes of cost estimating, it was assumed that 15 miles of new transmission lines would be constructed. The location and nature of the connection to an existing power grid would need to be determined as part of a detailed feasibility study. Costs associated with transmission lines could include construction of new lines or reconductoring of existing lines. The limited data obtained during this study were not adequate to make this determination.

C. PROPOSED PROJECT

Two conceptual layouts were considered for the Middle Creek Project. One layout would have the powerhouse at the base of the dam, while the other layout would use a long penstock to carry the flow about 40,000 feet downstream from the powerhouse. Both projects are described below.

1. Project Description - Upstream Site

A 54 inch liner would be installed inside the existing outlet works. This liner would be welded to the existing steel liner. A fixed wheel gate would be installed at the outlet to allow the passage of flood flows. Upstream from the fixed wheel gate, a 39 inch diameter penstock would bifurcate to the powerhouse, which would be located to the right of the existing outlet works. The powerhouse would contain a single horizontal Francis turbine and would discharge to Middle Creek downstream from the existing outlet works. The arrangement of the facilities is shown as Figure V-1.

2. Project Description - Downstream Site

This alternative would be similar to the upstream site described above, but would have a much longer penstock and would utilize an impulse turbine. About 40,000 feet of penstock and access road would be constructed. The fixed wheel gate near the dam would be replaced with a pressure regulating valve for passing flood flows and maintaining minimum streamflows; however, the synchronous bypass valve at the powerhouse would not be needed because the impulse turbine would use a deflector to divert the flow in the case of emergency shutdown. A pressure regulating valve would be required near the existing outlet works in order to maintain flows in the 40,000 feet of stream between the dam and power plant. Only about seven miles of new transmission lines would be required for this atlernative.

3. Hydrology and Hydraulics

Middle Creek Reservoir is located on Hyalite Creek, which is a tributary of the Missouri River. The reservoir is in Gallatin County, 15 miles south of Bozeman, Montana. The altitude of the reservoir, at spillway crest, is about 6,700 feet NGVD. The reservoir provides irrigation and municipal benefits. The United States Geological Survey (USGS) maintains a stream gage on Hyalite Creek about 7 miles downstream of the reservoir. The altitude of this stream gage is about 5,540 feet NGVD. A reservoir level gage and two stream gages located 1 mile upstream of the reservoir on the East and West Fork of Hyalite Creek are maintained by the Montana Department of Natural Resources and Conservation (DNRC). These two gages on the East and West Forks of Hyalite Creek were installed in October 1974. Due to the short period of record, the two gages maintained by DNRC were not used in this study.

The discharge downstream from the dam was based on the USGS stream gage records for "Hyalite Creek at Hyalite Ranger

Station, near Bozeman, MT", No. 06050000. The drainage area above this gage is 48.2 square miles. The total drainage area above Middle Creek Reservoir is 27.8 square miles. The outflow from the reservoir was estimated based on the USGS gage records adjusted for the difference in drainage areas (i.e. Reservoir outflow = (27.8/48.2) * (USGS flows)). This approximation does not account for reservoir storage and is probably very conservative. Continuous USGS gage records are available since 1934.

The period of record used in this study was January 1964 to December 1973, in order to reflect current demands and to incorporate a typical dry year, 1973, and wet year, 1964, (personal conversation with Mr. Steve Fry, DNRC). The Department maintains streamgages on both the East and West Forks of Hyalite Creek, above the reservoir. These gages were installed in 1974 and have been published by the Department for the years 1975 and 1976. This period of record does not provide an adequate indication of the pattern of historical discharges. The estimated maximum and minimum discharges at the reservoir site were about 550 cfs and 3 cfs respectively. The estimated average discharge over the 46 year period of record at the reservoir site was about 40 cfs.

The water surface level in the reservoir is recorded by DNRC gage 41H01900 "Middle Creek Reservoir". Records have been maintained for this reservoir since April 1951. The maximum observed reservior contents were 8,240 AF on May 31, 1966. The total storage available in the reservoir is 8,239 AF at the spillway crest elevation 6,700 feet NGVD (200.75 feet DNRC contour). Of this total storage, 209 AF are dead storage, below the intake invert elevation of 6,624 feet NGVD (125 feet DNRC contour).

The water surface elevation downstream from the outlet works varies from about elevation 6,595 feet NGVD at zero discharge to elevation 6,598 at about 550 cfs.

For purposes of estimating installed capacities, power production and energy production, the historical records of flows and reservoir elevations for the years 1964 through 1973 were used as a basis to develop an annual hydrograph of average monthly flows at the reservoir site, and an average monthly record of water surface elevations. These values are shown graphically on Figure V-2. The estimated average annual discharge from the reservoir for this 10 year period of record was about 46 cfs. This average discharge is about 15 percent higher than the long-term average.

4. Power Study

The average annual hydrograph and average record of monthly water surface elevations described above were used to estimate the installed capacity and annual average energy production for the Middle Creek Project. This determination was made based on typical turbine performance characteristics and the physical characteristics of each site. The head available for power production was estimated as the difference between the headwater and tailwater elevation minus an allowance for head losses. The capacity of the plant was not optimized; however, an attempt was made to select the turbine so that its operation would encompass a wide variation of head and flow.

For the upstream site, a horizontal Francis type turbine with a rated head of 90 feet, rated flow of 100 cfs, and rated capacity of 650 kilowatts was selected. This unit was selected because the head available for power production at this site is clearly in the normal operation range of Francis turbines, and the horizontal configuration has cost saving advantages over a vertical unit. The savings are due to decreased excavation and the ability to complete most of the powerhouse construction prior to delivery of the turbine. The turbine would produce power for six months during an average year and would produce

approximately 1.9 million kilowatt-hours annually. The average annual plant factor for the site would be about 33 percent.

The head available for power production at the downstream site is about 1,000 feet; for this installation, an impulse turbine was selected. The turbine selected has a rated flow of 30 cfs, rated head of about 1,000 feet, and rated capacity of 2,150 kW. The lower rated flow was selected for this alternative because the plant would be able to operate year round, and would produce an average of 11.9 million kilowatt hours annually. The average annual plant factor for the site would be 63 percent.

5. Cost Estimates

The total project capital cost consists of the direct construction cost; the associated indirect costs for engineering, management and administration; and interest during construction. These cost estimates for the Middle Creek Project are presented as Tables V-2 and V-3. This cost estimates are based on bid prices for similar construction work, recent manufacturers quotes for mehcanical and electrical equipment, and experience with other projects. The estimates also include allowances for contingencies and for the costs of engineering. The contingency allowance is 15 percent of the mechanical and electrical costs plus 20 percent of all other costs. The engineering costs cover actiivities which include detailed feasibility studies, obtaining miscellaneous licenses and permits, final design, contract plans and specifications, and engineering services during construction. This amount was estimated as 25 percent of the direct construction cost plus contingencies. An allowance was also made for owner administration, financial, and legal expenses. Interest during construction was based on an 18-month construction period and 12 percent interest. Interest income on retained funds was not

considered, and the calculation of interest during construction is very conservative.

The cost estimates are presented at July 1982 price levels. The estimated total project capital cost for the Middle Creek Project upstream alternative is $2,527,600, and the total capital cost for the downstream alternative is $14,034,300. These costs would be $2,948,200 and $16,373,100 if escalated to July 1984 at eight percent annual inflation. The difference in cost of the two projects is primarily due to construction of additional penstock and road.

6. Economic Analysis

The benefits and costs associated with the Middle Creek Hydroelectric Project were assessed in order to determine the overall economic feasibility of each alternative. The project capital costs were escalated to July, 1984, at eight percent annual interest; this is the proposed bid date for the project. The value of power was escalated at ten percent annual interest to January 1986, the proposed on-line date for the project. It was assumed that the project would be financed with bonds having a life of 35 years and bearing a 12 percent interest rate. The cost of operation and maintenance for the first year of operation would be 1.25 percent of the capital cost plus contingencies. The annual costs of the alternative projects for the first year of operation (1986) are presented as Tables V-4 and V-5.

It was assumed that the rate of general inflation is eight percent and that energy would escalate at ten percent annually. Inflation was considered for 10 years beyond the proposed on-line date of January 1986 and then held constant. All costs were discounted to January 1986 at 12 percent annual interest and the present worth of the benefits was compared to the present worth of costs to produce a benefit/cost (B/C)

ratio for each alternative project. The B/C calculations are presented as Tables V-6 and V-7 and the economic features of the projects are summarized on Table V-8. The B/C ratios for the upstream and downstream alternatives are 0.55 and 0.63, respectively.

D. ENVIRONMENTAL OVERVIEW

1. Overview

Middle Creek Reservoir is located in the Gallatin River Basin in south central Montana near Bozeman. It is situated in a valley containing snow-fed mountain streams that originate in a glaciated bowl on the east slope of the Rocky Mountains. With a crest elevation of 6,699 feet, the surrounding vegetation is predominately ponderosa pine. The reservoir is used to supply supplemental water to the city of Bozeman, as well as for irrigation, flood control, and recreation.

Both the reservoir and the stream below are fairly pristine. The reservoir supports an excellent population of cutthroat trout and Arctic greyling. The greyling population is one of the few found in a lake in the state. The fish live in the reservoir and spawn in the tributaries above. The Department of Fish, Wildlife and Parks formerly stocked the reservoir with cutthroat trout, but have now apparently been successful in establishing a wild fishery (Vincent, pers. commun., 1982). Middle Creek below the dam supports a reasonably good fishery of cutthroat, rainbow, and brook trout. The area is heavily used for recreation because of its proximity to Bozeman. Ice fishing is becoming an increasingly important sport at the lake.

No water quality problems have been experienced at the reservoir, nor have any fish kills been noted (Vincent, pers. commun., 1982). The Water Quality Bureau of the Montana

Department of Health and Environmental Sciences classifies the river as B-1. Dissolved oxygen and temperature standards for this classification are presented in Table V-9. Ice covers the lake from November through May. If stratification does take place, dissolved oxygen concentrations could be expected to dip lowest in March and April.

Abundant wildlife inhabits the area including deer, moose, and elk. The reservoir and creek, however, support no major waterfowl nesting area.

Two archaeologic sites have been recorded in the vicinity of the project area. The Rocky Mountain region is rich in cultural and historical resources, particularly along creek beds. Therefore, a survey of the area may uncover other sites of interest.

2. Potential Problems

The environmental characteristics of the site suggest that potential problems would be minimal. In this study, it was assumed that historical outflows would be maintained, the elevation of the intake for the outlet works would not change, and that most of the spilled flow would be diverted through the power plant. This latter change may cause a slight reduction in the concentration of dissolved oxygen in the discharge water, but should not affect the value of the fishery habitat below the dam. Temperature of the discharge water may differ slightly from that of the receiving water, but should still meet the established water quality standards. Water levels in the reservoir and downstream should not vary from what has been experienced in the past.

Construction activities are a potential threat to the fishery in the reservoir and below the dam. Scheduling the construction to periods when fish are not spawning or flows are

low would minimize interference. Minimum flows would no doubt be required below the dam throughout the construction period. Standard sediment control practices should minimize any potential turbidity problems.

A 15-mile transmission line is planned. This corridor could potentially interfere with wildlife by intersecting major migration routes or disturbing nesting or denning areas. Further, archaeological resources may be encountered along the route and provisions should be made to recover them or avoid sensitive areas altogether. A survey of the corridor may be required before an exemption application can be filed.

3. Recommended Action

This project does not appear to be feasible and no further action is recommended at the present time.

E. CONCLUSIONS AND RECOMMENDATIONS

The Middle Creek Hydroelectric Project is not an economically viable project. No further action is recommended at this site.

TABLE V-1

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF PHYSICAL FEATURES
MIDDLE CREEK HYDROELECTRIC PROJECT

Upstream Alternative

Turbine Type:	Horizontal Francis
Turbine Capacity:	650 kW (one unit)
Rated Head:	90 ft
Rated Flow:	100 cfs
Average Annual Energy:	1.9 GWh

Downstream Alternative

Turbine Type:	Impulse
Turbine Capacity:	2,150 kW (one unit)
Rated Head:	1,000 ft
Rated Flow:	30 cfs
Average Annual Energy:	11.9 GWh

TABLE V-2

MONTANA HYDROELECTRIC RECONNAISSANCE
PROJECT CAPITAL COSTS
MIDDLE CREEK
UPSTREAM ALTERNATIVES

	Item	Cost
1.	Structures and Improvements	$ 271,650
2.	Reservoirs, Dams, and Waterways	259,800
3.	Turbines and Generators	200,000
4.	Accessory Electrical Equipment	150,000
5.	Miscellaneous Mechanical Equipment	15,000
6.	Switchyard	30,000
7.	Transmission Lines	450,000
	Direct Construction Cost	1,376,500
	Contingencies	255,500
	Subtotal	1,632,000
	Engineering (25%)	408,000
	Subtotal	2,040,000
	Administrative, Legal, and Financial (5%)	102,000
	Subtotal	2,142,000
	Interest During Construction	385,600
	TOTAL PROJECT CAPITAL COST (July 1982)	$2,527,600
	TOTAL PROJECT CAPITAL COST (Escalated to July 1984 at 8% annual inflation)	$2,948,200

TABLE V-3

MONTANA HYDROELECTRIC RECONNAISSANCE
PROJECT CAPITAL COSTS
MIDDLE CREEK
DOWNSTREAM ALTERNATIVE

	Item	Cost
1.	Structures and Improvements	$ 271,650
2.	Reservoirs, Dams, and Waterways	6,116,200
3.	Turbines and Generators	730,000
4.	Accessory Electrical Equipment	200,000
5.	Miscellaneous Mechanical Equipment	25,000
6.	Switchyard	40,000
7.	Transmission Lines	210,000
	Direct Construction Cost	7,592,850
	Contingencies	1,468,800
	Subtotal	9,061,650
	Engineering (25%)	2,265,400
	Subtotal	11,327,100
	Administrative, Legal, and Financial (5%)	566,400
	Subtotal	11,893,500
	Interest During Construction	2,140,800
	TOTAL PROJECT CAPITAL COST (July 1982)	14,034,300
	TOTAL PROJECT CAPITAL COST (Escalated to July 1984 at 8% annual inflation)	16,373,100

TABLE V-4

ESTIMATED ANNUAL COST

MIDDLE CREEK HYDROELECTRIC PROJECT
(UPSTREAM ALTERNATIVE)

1.	Total Project Capital Cost escalated to July, 1984		$2,948,200
2.	Estimated Cost of Capital:	12%	
3.	Economic Life of Project:	50 Years	
4.	Annual Costs		
	4.1 Amortization Cost[1]		360,600
	4.2 O, M & R[2]		23,800
			$ 384,400
5.	Estimated Average Annual Generation		
	1,860,000 kWh/Annum		
6.	Unit Cost of Power		

$$\frac{\$\ 384,400}{1,860,000} \times 1,000 = 206.7 \text{ mills/kWh}$$

---

1. Amortized for 35 years at 12 percent.

2. 1.25 percent of Capital Cost plus contingency, escalated to July, 1984.

TABLE V-5

ESTIMATED ANNUAL COST

MIDDLE CREFK HYDROELECTRIC PROJECT
(DOWNSTREAM ALTERNATIVE)

1.	Total Project Capital Cost escalated to July, 1984		$16,373,100
2.	Estimated Cost of Capital:	12%	
3.	Economic Life of Project:	50 Years	
4.	Annual Costs		
	4.1 Amortization Cost[1]		2,002,400
	4.2 O, M & R[2]		132,100
			$2,134,500
5.	Estimated Average Annual Generation		
	11,880,000 kWh/Annum		
6.	Unit Cost of Power		

$$\frac{\$\ 2,134,500}{11,880,000} \times 1,000 = 179.7 \text{ mills/kWh}$$

1. Amortized for 35 years at 12 percent.

2. 1.25 percent of Capital Cost plus contingency, escalated to July, 1984.

TABLE V-6

Benefit/Cost Analysis - Tudor Engineering Company

MIDDLE CREEK UPSTREAM ALTERNATIVE - STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

JULY 1982

Year	Cost Streams		Benefit Stream (*)	Present Worth Factor (*)	Present Worths	
	Debt Service	OM&R (*)			Cost	Benefit
1986	360600	23800	122800	1.00000	384400	122800
1987	360600	25700	135100	0.89286	344900	120600
1988	360600	27800	148600	0.79719	309600	118500
1989	360600	30000	163400	0.71178	278000	116300
1990	360600	32400	179800	0.63552	249700	114300
1991	360600	35000	197800	0.56743	224500	112200
1992	360600	37800	217500	0.50663	201800	110200
1993	360600	40800	239300	0.45235	181600	108200
1994	360600	44100	263200	0.40388	163400	106300
1995	360600	47600	289600	0.36061	147200	104400
1996	360600	47600	289600	0.32197	131400	93200
1997	360600	47600	289600	0.28748	117300	83200
1998	360600	47600	289600	0.25668	104800	74300
1999	360600	47600	289600	0.22917	93500	66400
2000	360600	47600	289600	0.20462	83500	59200
2001	360600	47600	289600	0.18270	74600	52900
2002	360600	47600	289600	0.16312	66600	47200
2003	360600	47600	289600	0.14564	59400	42200
2004	360600	47600	289600	0.13004	53100	37700
2005	360600	47600	289600	0.11611	47400	33600
2006	360600	47600	289600	0.10367	42300	30000
2007	360600	47600	289600	0.09256	37800	26800
2008	360600	47600	289600	0.08264	33700	23900
2009	360600	47600	289600	0.07379	30100	21400
2010	360600	47600	289600	0.06588	26900	19100
2011	360600	47600	289600	0.05882	24000	17000
2012	360600	47600	289600	0.05252	21400	15200
2013	360600	47600	289600	0.04689	19100	13600
2014	360600	47600	289600	0.04187	17100	12100
2015	360600	47600	289600	0.03738	15300	10800
2016	360600	47600	289600	0.03338	13600	9700
2017	360600	47600	289600	0.02980	12200	8600
2018	360600	47600	289600	0.02661	10900	7700
2019	360600	47600	289600	0.02376	9700	6900
2020	360600	47600	289600	0.02121	8700	6100
2021	0	47600	289600	0.01894	900	5500
2022	0	47600	289600	0.01691	800	4900
2023	0	47600	289600	0.01510	700	4400
2024	0	47600	289600	0.01348	600	3900
2025	0	47600	289600	0.01204	600	3500
2026	0	47600	289600	0.01075	500	3100
2027	0	47600	289600	0.00960	500	2800
2028	0	47600	289600	0.00857	400	2500
2029	0	47600	289600	0.00765	400	2200
2030	0	47600	289600	0.00683	300	2000
2031	0	47600	289600	0.00610	300	1800
2032	0	47600	289600	0.00544	300	1600
2033	0	47600	289600	0.00486	200	1400
2034	0	47600	289600	0.00434	200	1300
2035	0	47600	289600	0.00388	200	1100
				Totals	3646500	1994700

Benefit/Cost Ratio = 1994700/3646500 = .55

* Note:

OM&R Escalation Rate = 8 % for years 1 - 10
OM&R Escalation Rate = 0 % for years 11 - 50

Power Revenue Escalation Rate = 10 % for years 1 - 10
Power Revenue Escalation Rate = 0 % for years 11 - 50

Discount Rate = 12 % for years 1 - 50

TABLE V-7

Benefit/Cost Analysis - Tudor Engineering Company

MIDDLE CREEK DOWNSTREAM ALTERNATIVE - STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

JULY 1982

Year	Cost Streams		Benefit Stream (*)	Present Worth Factor (*)	Present Worths	
	Debt Service	OM&R (*)			Cost	Benefit
1986	2002400	132100	784100	1.00000	2134500	784100
1987	2002400	142700	862500	0.89286	1915200	770100
1988	2002400	154100	948800	0.79719	1719100	756300
1989	2002400	166400	1043600	0.71178	1543700	742800
1990	2002400	179700	1148000	0.63552	1386800	729600
1991	2002400	194100	1262800	0.56743	1246400	716500
1992	2002400	209600	1389100	0.50663	1120700	703800
1993	2002400	226400	1528000	0.45235	1008200	691200
1994	2002400	244500	1680800	0.40388	907500	678800
1995	2002400	264100	1848900	0.36061	817300	666700
1996	2002400	264100	1848900	0.32197	729700	595300
1997	2002400	264100	1848900	0.28748	651600	531500
1998	2002400	264100	1848900	0.25668	581700	474600
1999	2002400	264100	1848900	0.22917	519400	423700
2000	2002400	264100	1848900	0.20462	463800	378300
2001	2002400	264100	1848900	0.18270	414100	337800
2002	2002400	264100	1848900	0.16312	369700	301600
2003	2002400	264100	1848900	0.14564	330100	269300
2004	2002400	264100	1848900	0.13004	294700	240400
2005	2002400	264100	1848900	0.11611	263200	214700
2006	2002400	264100	1848900	0.10367	235000	191700
2007	2002400	264100	1848900	0.09256	209800	171100
2008	2002400	264100	1848900	0.08264	187300	152800
2009	2002400	264100	1848900	0.07379	167200	136400
2010	2002400	264100	1848900	0.06588	149300	121800
2011	2002400	264100	1848900	0.05882	133300	108800
2012	2002400	264100	1848900	0.05252	119000	97100
2013	2002400	264100	1848900	0.04689	106300	86700
2014	2002400	264100	1848900	0.04187	94900	77400
2015	2002400	264100	1848900	0.03738	84700	69100
2016	2002400	264100	1848900	0.03338	75700	61700
2017	2002400	264100	1848900	0.02980	67500	55100
2018	2002400	264100	1848900	0.02661	60300	49200
2019	2002400	264100	1848900	0.02376	53800	43900
2020	2002400	264100	1848900	0.02121	48100	39200
2021	0	264100	1848900	0.01894	5000	35000
2022	0	264100	1848900	0.01691	4500	31300
2023	0	264100	1848900	0.01510	4000	27900
2024	0	264100	1848900	0.01348	3600	24900
2025	0	264100	1848900	0.01204	3200	22300
2026	0	264100	1848900	0.01075	2800	19900
2027	0	264100	1848900	0.00960	2500	17700
2028	0	264100	1848900	0.00857	2300	15800
2029	0	264100	1848900	0.00765	2000	14100
2030	0	264100	1848900	0.00683	1800	12600
2031	0	264100	1848900	0.00610	1600	11300
2032	0	264100	1848900	0.00544	1400	10100
2033	0	264100	1848900	0.00486	1300	9000
2034	0	264100	1848900	0.00434	1100	8000
2035	0	264100	1848900	0.00388	1000	7200
				Totals	20247800	12736300

Benefit/Cost Ratio = 12736300/20247800 = .63

* Note:

OM&R Escalation Rate = 8 % for years 1 - 10
OM&R Escalation Rate = 0 % for years 11 - 50

Power Revenue Escalation Rate = 10 % for years 1 - 10
Power Revenue Escalation Rate = 0 % for years 11 - 50

Discount Rate = 12 % for years 1 - 50

TABLE V-8

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF ECONOMIC FFATURES
MIDDLE CREFK HYDROELECTRIC PROJECT

Upstream Alternative

Interest Rate:	12%
Total Project Cost:	$2,948,200
Annual Debt Service:	360,600
Annual Operation and Maintenance:	23,800
Total Annual Cost:	384,400
Production Cost, Mills/kWh:	206.7
Production Cost, $/kW:	4,536
Power Value, Mills/kWh:	66
Benefit/Cost Ratio:	0.55

Downstream Alternative

Interest Rate:	12%
Total Project Cost:	$16,373,100
Annual Debt Service:	2,002,400
Annual Operation and Maintenance:	132,100
Total Annual Cost:	2,134,500
Production Cost, Mills/kWh:	179.7
Production Cost, $/kW:	7,615
Power Value, Mills/kWh:	66
Benefit/Cost Ratio:	0.63

TABLE V-9

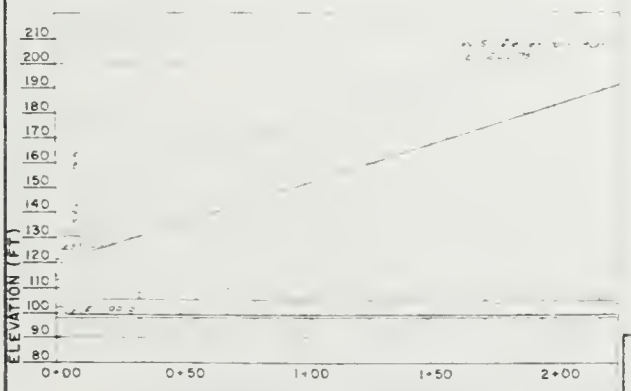
MONTANA HYDROELECTRIC RECONNAISSANCE
DISSOLVED OXYGEN AND
TEMPERATURE STANDARDS
MIDDLE CREEK HYDROELECTRIC PROJECT

Parameter	Standard
Dissolved Oxygen	• Cannot fall below 7 mg/l.
Temperature	• No more than 1 degree increase when the water temperature is 32 to 36° F.
	• Cannot exceed 67° F when the water temperature is 66 to 66.5° F.
	• No more than a 0.5 degree increase when the water temperature is above 66.5° F.
	• No more than a 2 degree decrease per hour when the water temperature is above 55 F.
	• Cannot decrease more than 2 degrees when the water temperature is 55 to 32° F.

Source: Horpestad, pers. commun., 1982.

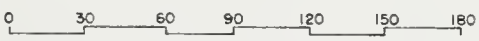
GENERAL PLAN

SCALE: 1" = 100'

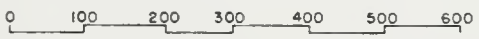


LOCATION MAP

VICINITY MAP



SCALE 1" = 30'



SCALE 1" = 100'

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

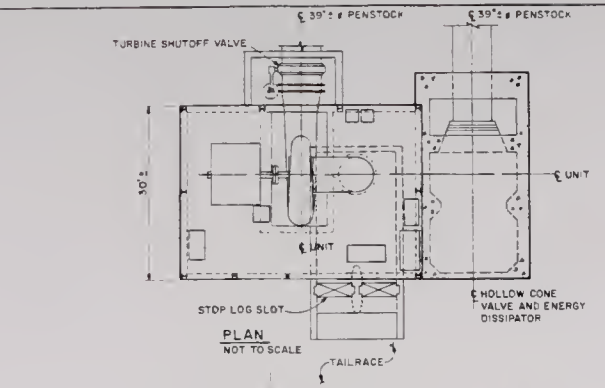
MONTANA HYDROELECTRIC RECONNAISSANCE

MIDDLE CREEK HYDROELECTRIC PROJECT

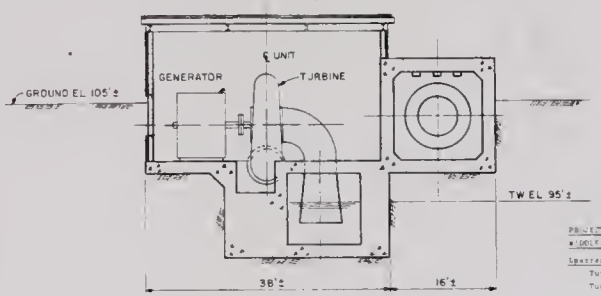
TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

FIGURE V-1

GENERAL PLAN
SCALE 1" = 100'



PLAN
NOT TO SCALE

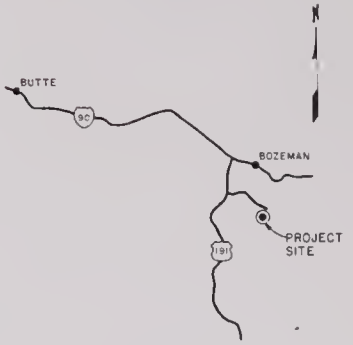


SECTION ALONG CENTERLINE OF POWERHOUSE
NOT TO SCALE

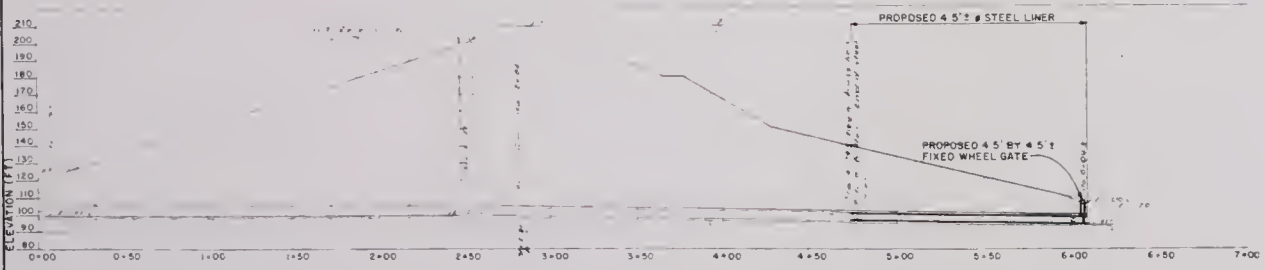
PROJECT DATA
MIDDLE CREEK HYDROELECTRIC PROJECT

Upstream Alternative	
Turbine Type	Horizontal Francis
Turbine Capacity	650 kW (one unit)
Rated Head	90' ft
Rated Flow	100 cfs
Average Annual Energy	4.9 GWh
Downstream Alternative	
Turbine Type	Impulse
Turbine Capacity:	9,140 kW (one unit)
Rated Head:	1,000 ft
Rated Flow	30 cfs
Average Annual Energy:	11.9 GWh

LOCATION MAP



VICINITY MAP



PROFILE
SCALE 1" = 30'

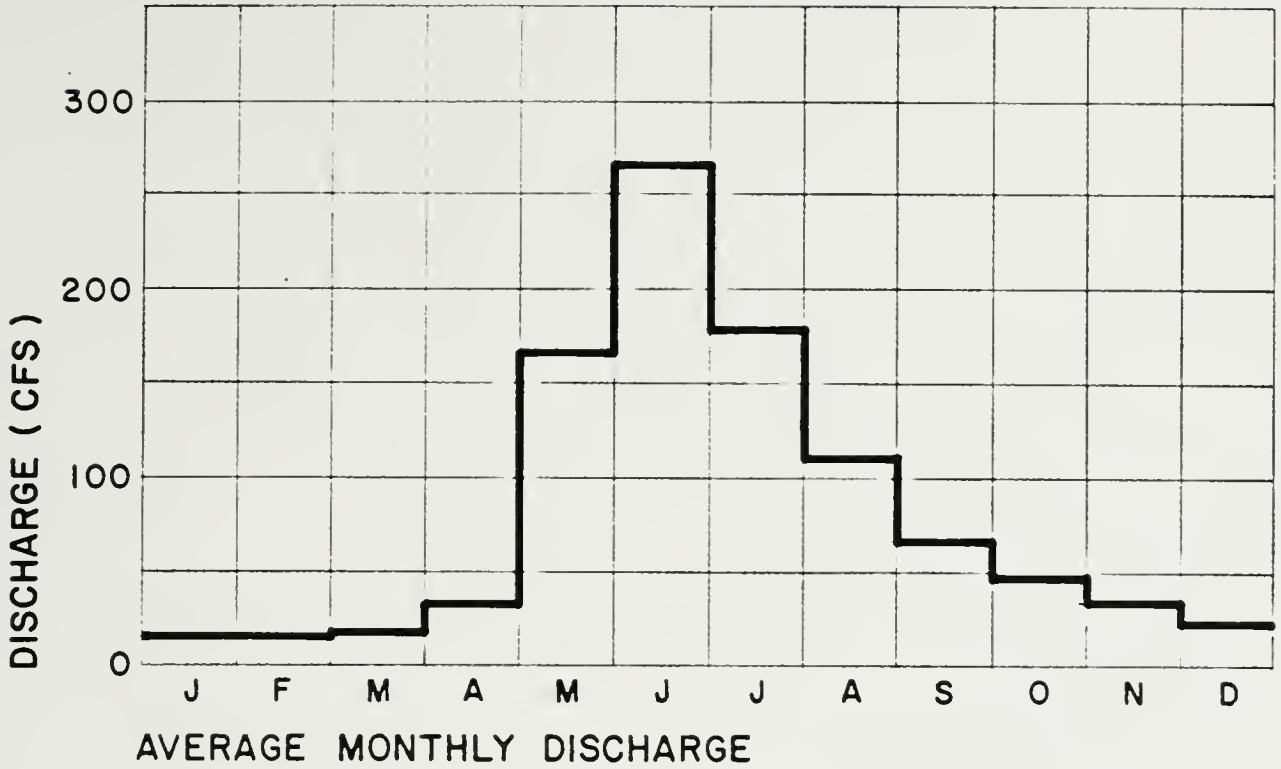
0 30 60 90 120 150 180
SCALE 1" = 30'

0 100 200 300 400 500 600
SCALE 1" = 100'

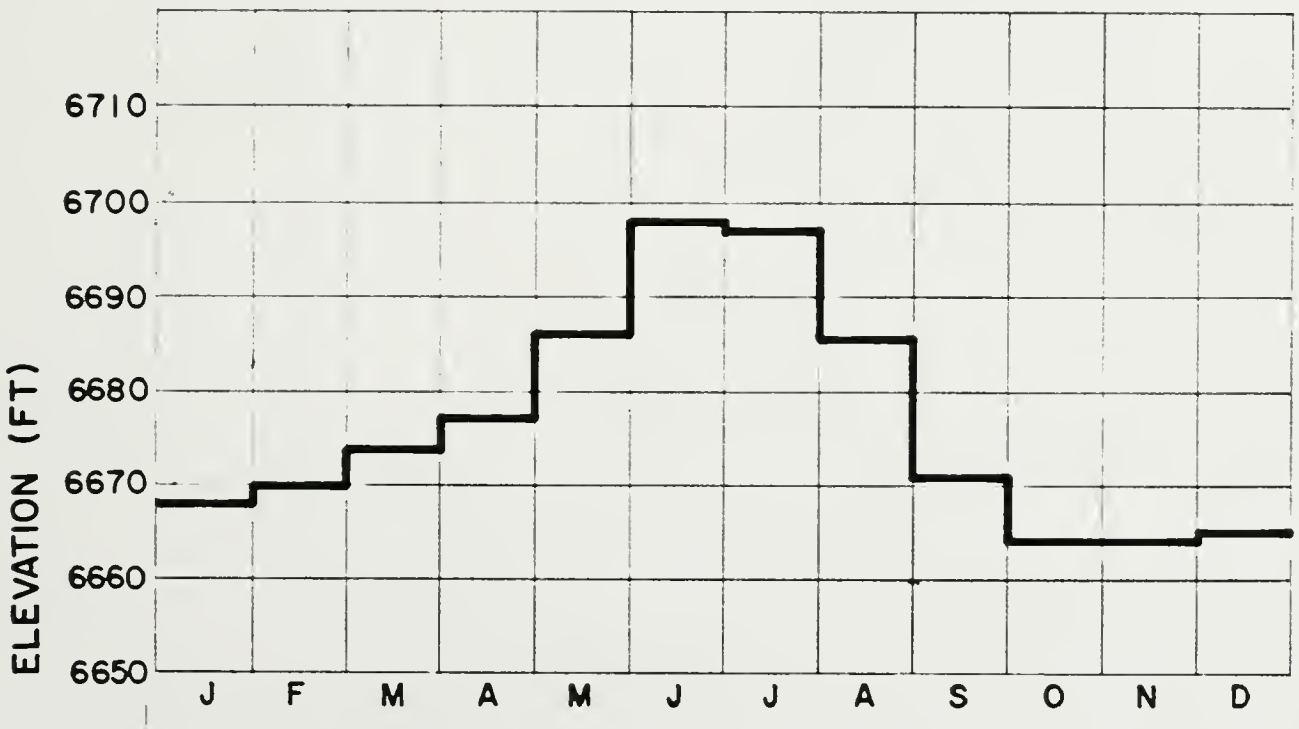
NOTE:
DAM CREST EL 210' (DNR & C DATUM) = EL 6710' MSL

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA
MONTANA HYDROELECTRIC RECONNAISSANCE
MIDDLE CREEK HYDROELECTRIC PROJECT
TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

FIGURE V-1



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

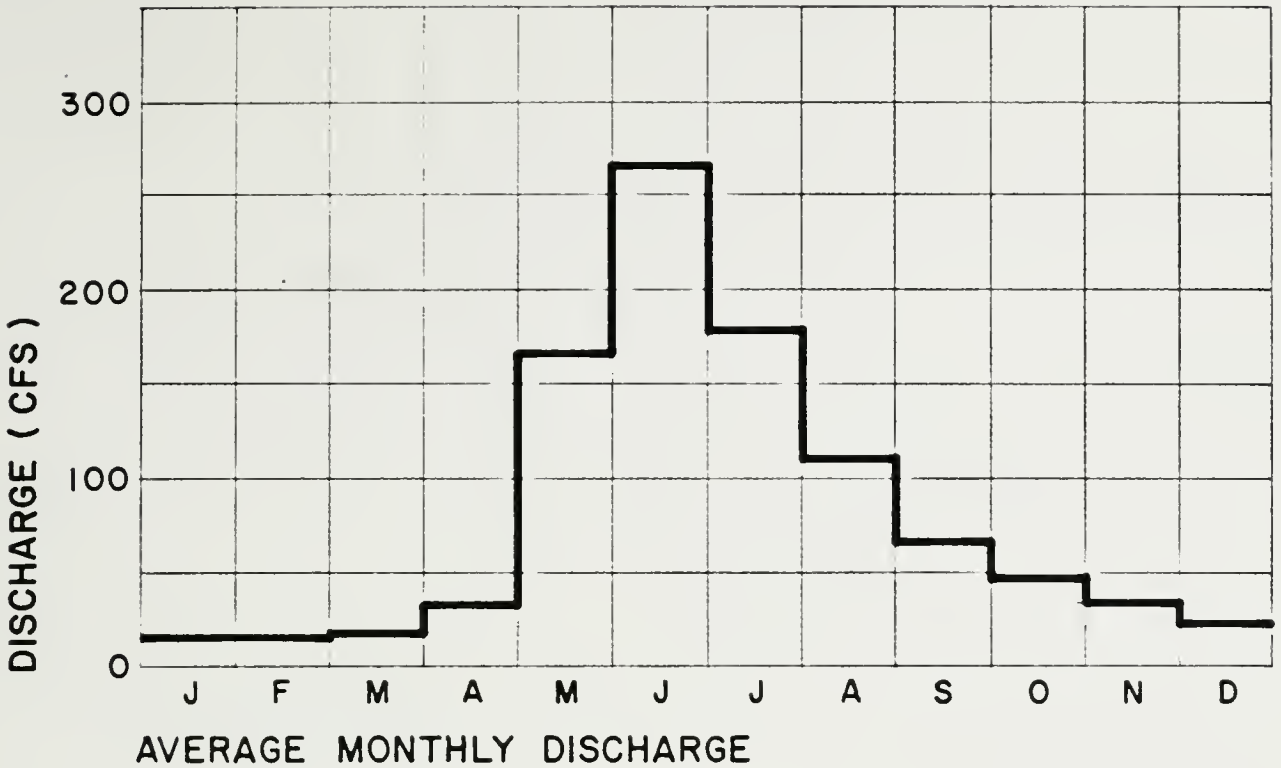
STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

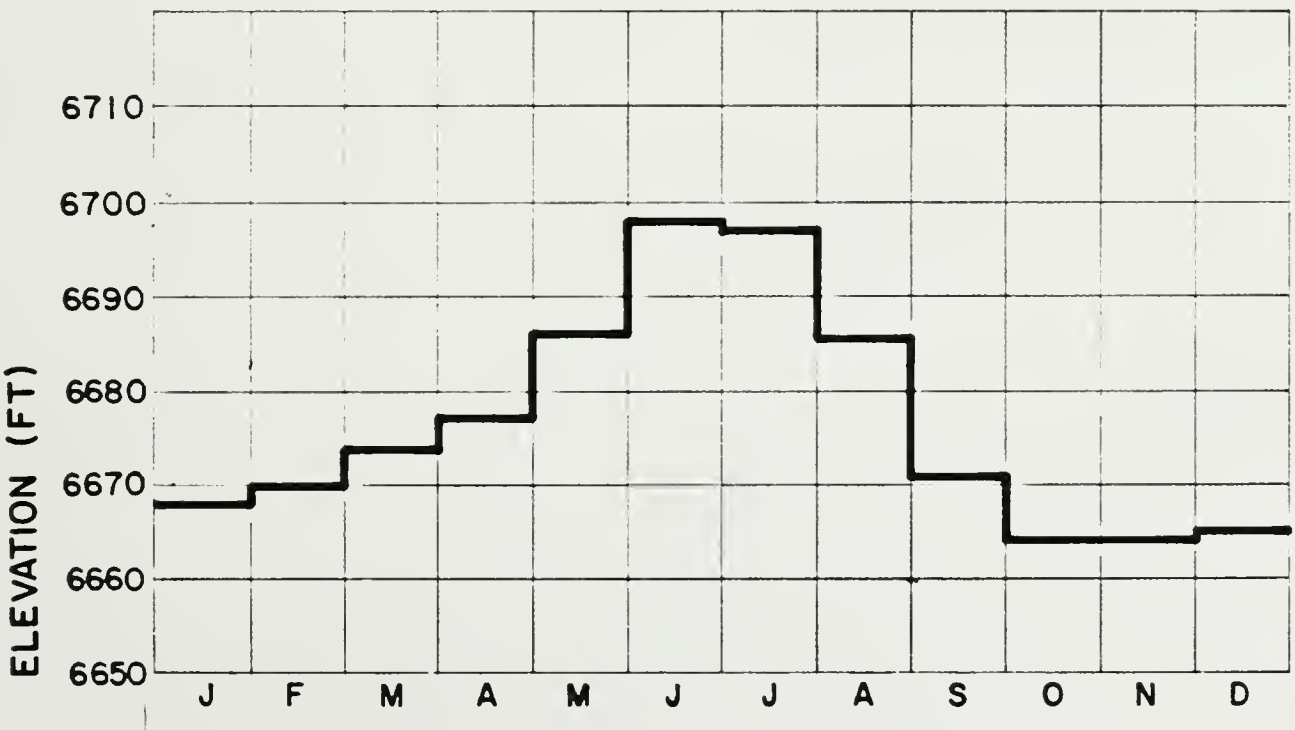
MIDDLE CREEK

FIGURE

V-2



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

MIDDLE CREEK

FIGURE

V-2

COONEY DAM AND RESERVOIR

COONEY DAM OUTLET WORKS

SECTION VI
COONEY DAM HYDROELECTRIC PROJECT

A. GENERAL

The Cooney Dam Hydroelectric Project would be located at Cooney Dam, an earthfill structure on Red Lodge Creek 6.6 miles west of Boyd, Montana. The dam is in Carbon County. The reservoir impounded by the dam is used primarily for irrigation storage; however, recreational benefits are also associated with the existing project. The proposed project would utilize flow releases through the dam outlet works to produce, on the average, approximately 4.5 million kilowatt-hours of electrical energy annually.

B. EXISTING FACILITIES

The main features of the Cooney Dam Hydroelectric Project are the dam, reservoir, spillway, and outlet works. Additional existing features significant to the development of a hydroelectric project include access to the site and the existence of electrical transmission lines. The existing facilities are described in more detail below. The arrangement of the facilities is shown on Figure VI-1.

1. Dam

Cooney Dam is a zoned earthfill embankment with a maximum structural height of 103 feet and a crest length of 2,300 feet at elevation 4,265.0 feet. The dam has a crest width of 26 feet and was placed on a slope of 2.25:1 on the upstream face and 2:1 on the downstream face.

The principal spillway is located approximately 1,230 feet to the left of the dam abutment (looking downstream), and the

outlet works is located at the right abutment. The dam and spillway have recently undergone modifications which increased the dam crest elevation to 4,265 feet and the principal spillway crest elevation to 4247.25 feet. The principal spillway is 70 feet wide at the crest and consists of two drop sections. An auxiliary spillway, located about 400 feet northwest of the principal spillway, is designed to operate in emergencies and is equipped with a fuse plug. The top of the fuse plug embankment varies from elevation 4,253.2 to 4,257.2 feet.

The outlet works intake is located near the right abutment of the dam. An approach channel at about elevation 4,173 feet delivers flow from the bottom of the reservoir to a box type intake structure with trash racks. The flow is discharged through a curved 6 foot diameter horseshoe tunnel. The total length of the tunnel is about 630 feet; of this total, 200 feet are upstream from the outlet control gates and are pressurized, and 430 feet are downstream from the control gates and operate under open channel flow conditions. The outlet tunnel is controlled by a 60-inch butterfly valve, and a 60-inch slide gate is located upstream of this butterfly valve to provide emergency closure capability. The tunnel discharges into the stilling basin at about elevation 4,173. The Dam Safety Report (1978) indicates that the maximum outlet capacity is about 900 cfs, but discharges in excess of about 150 cfs create erosion of the weathered channel material downstream. This report also notes that discharges in excess of about 460 cfs would overtop the weir structure located downstream of the dam and could create additional erosion problems.

2. Site Access

Existing dirt roads currently provide access to the crest of the dam and to the toe of the dam. These roads would provide adequate access to the powerhouse location for construction, operation, and maintenance of the project.

3. Transmission Lines

It is anticipated that transmission lines with adequate capacity for the transmission of power from the Cooney Dam Project exist in the immediate area of the project. The project is in the Montana Power Company service area. In addition to local electrical distribution lines, the Montana Power Company owns a major transmission line within eight miles of the project. For purposes of estimating the project cost, it has been assumed that it will be necessary to construct approximately one mile of new transmission lines. The exact nature and location of the connection to the existing grid would need to be determined as part of a detailed feasibility study. Costs associated with transmission lines could include construction of new lines or reconductoring of existing lines. The limited data obtained during this study were not adequate to make this determination.

C. PROPOSED PROJECT

A conceptual level layout of the Cooney Dam Hydroelectric Project was prepared for purposes of demonstrating the overall technical and economic feasibility of the project. No attempt was made to optimize the project configuration. Additional layouts should be considered as part of a detailed feasibility study.

1. Project Description

The Cooney Dam Hydroelectric Project would consist of a powerhouse containing two horizontal Francis turbines, each unit rated at 638 hp, and one 800 kW generator. Also included would be a steel liner in the existing outlet tunnel, a hollow cone valve with energy dissipator for flow bypass and pressure

regulation purposes, a tailrace channel, a switchyard and an access road.

The proposed layout is shown in Figure VI-1. Approximately 430 feet of outlet conduit would be lined with a 54-inch diameter steel penstock downstream of the existing gate structure. The annular space between the liner and existing concrete tunnel would be backfilled with grout and a drainage system installed. The outlet capacity would be somewhat reduced at extremely high flows; however, the Dam Safety Report (1978) indicates that it may not be advisable to pass high flows through this outlet, and recent modification to the spillway and dam should provide adequate capacity for passing flood flows.

Adjacent to the powerhouse would be a synchronous hollow cone bypass valve, with an energy dissipation chamber, which would open in the event of a turbine shutdown. The existing measuring weir would be removed and replaced with a lower weir. The channel would be excavated from the weir to the powerhouse at elevation 963, providing an additional eight feet of head. The switchyard would be located adjacent to the powerhouse and would contain the main power transformer, line disconnect switch, oil circuit breaker, revenue metering apparatus and other switching equipment. The significant physical features of the proposed project are summarized on Table VI-1, and are shown on Figure VI-1.

2. Hydrology and Hydraulics

Cooney Dam is located on Red Lodge Creek which is a tributary of the Clarks Fork Yellowstone River. Cooney Dam is located 6.6 miles west of Boyd, Montana, and one mile upstream from Cottonwood Creek. The United States Geological Survey (USGS) maintains a stream gage on Red Lodge Creek below the dam

and a reservoir level gage upstream from the dam is maintained by DNRC.

The discharge downstream from the dam is recorded by USGS stream gage 06212500 "Red Lodge Creek below Cooney Reservoir, near Boyd, Montana." The total drainage area above the site is 206 square miles. The altitude of the gage is about 4,140 feet. Records are available from October 1937 to the current year. Only one small unnamed dam (96 acre-feet) is located upstream of Cooney Dam on Butte Creek. The maximum and minimum discharges over the period of record were 3,470 cfs on June 15, 1967 and zero cfs in October 1948 and 1975. The average discharge over the 41-year period of record was 101 cfs.

The water surface level in the reservoir is recorded by DNRC stream gage 43D07900, "Cooney Reservoir". Continuous records have been maintained for this reservoir since January 1960. The maximum observed reservoir contents were 26,990 AF on June 15, 1967. The total storage available in the reservoir is 27,520 AF at the original top of 4-foot flashboards above spillway crest, elevation of 4,250 feet. Of this total, 120 AF are below the intake invert elevation of 4,175 feet.

Historically, the water surface elevation downstream from the outlet works varies from about elevation 4,163 feet at zero discharge to elevation 4,173 feet at a discharge of 3,470 cfs. The existing measuring weir would be removed in order to gain about 6 feet of additional head.

For purposes of estimating installed capacities, power production and energy production, the historical records of flows and reservoir elevations for the years 1964 through 1973 were used to develop an annual hydrograph of average monthly flows, and an average monthly record of water surface elevations. This 10-year period of record was chosen in order to reflect current irrigation demands and in order to incorporate

a drought year (1973) and a high flow year (1964). These values are shown graphically on Figure VI-2. The average annual flow for this period of time was about 110 cfs. This figure is within nine percent of the long-term average of 101 cfs and indicates that the hydrograph selected for the study is representative of the current demands and long-term average.

3. Power Study

The average annual hydrograph and average record of monthly water surface elevations described above were used to estimate the installed capacity and annual average energy production for the Cooney Dam Project. This determination was made based on typical turbine performance characteristics and the physical characteristics of the site. The head available for power production was estimated as the difference between the historical headwater and proposed tailwater elevation minus an allowance for head losses. The capacity of the plant was not optimized; however, an attempt was made to select the turbine so that its operation would encompass a wide variation of head and flow.

Two horizontal Francis type turbines with a rated head of 75 feet, rated flow of 75 cfs each and rated capacity of 400 kilowatts each (800 kW total) were selected for the Cooney site. Horizontal Francis units were selected because the head and flow available for power production are in the range of normal operation for Francis units, and because of savings in civil costs that are possible with the horizontal configuration. The horizontal configuration requires less excavation than a vertical configuration, and it also allows for most of the powerhouse to be built before the turbine is delivered. Two 400 kW units were chosen, instead of one larger unit, in order to generate electricity at the low discharges in the 30 to 75 cfs ranges, which occur about six months out of the year. The turbines would produce power year-round during an

average year and would produce approximately 4.5 million kilowatt-hours annually. The average annual plant factor for the site would be about 64 percent.

4. Cost Estimate

The total project capital cost consists of the direct construction cost; the associated indirect costs for engineering, management and administration; and interest during construction. The cost estimate for the Cooney Dam Project is presented as Table VI-2. This cost estimate is based on bid prices for similar construction work, recent manufacturers quotes for mechanical and electrical equipment, and experience with other projects. The estimate also includes allowances for contingencies and for the costs of engineering. The contingency allowance is 15 percent of the mechanical and electrical costs plus 20 percent of all other costs. The engineering costs cover activities which include detailed feasibility studies, obtaining miscellaneous licenses and permits, final design, contract plans and specifications, and engineering services during construction. This amount was estimated as 25 percent of the direct construction cost plus contingencies. An allowance was also made for owner administration, financial, and legal expenses. Interest during construction was based on an 18-month construction period and 12 percent interest. No allowance was made for interest income on retained funds, and the calculation of interest during construction is therefore conservative.

The cost estimate is presented at July 1982 price levels. The estimated total project capital cost for the Cooney Dam Project is $2,175,200. This cost would be $2,537,200 if escalated to the proposed bid date of July 1984 at eight percent annual inflation.

5. Economic Analysis

The benefits and costs associated with the Cooney Dam Hydroelectric Project were assessed in order to determine the overall economic feasibility of the project. The project capital cost was esclated to July, 1984, at eight percent annual interest; this is the proposed bid date for the project. The value of power was escalated at ten percent annual interest to Janaury 1986, the proposed on-line date for the project. The difference in the rate of escalation of construction and energy costs reflects an apparent trend of energy costs to escalate at a more rapid rate than general inflation. It was assumed that the project would be financed with bonds having a life of 35 years and bearing a 12 percent interst rate. The cost of operation and maintenance for the first year of operation would be 1.25 percent of the capital cost plus contingencies. The annual costs of the Cooney Dam Project are summarized on Table VI-3.

As previously mentioned, it was assumed that the rate of general inflation is eight percent and that energy would escalate at ten percent annually. Inflation was considered for 10 years beyond the proposed on-line date of January 1986 and then held constant. All costs were discounted to January 1986 at 12 percent annual interest and the present worth of the benefits was compared to the present worth of costs to produce a benefit/cost (B/C) ratio for the project. The B/C calculation and a summary of economic features are presented as Tables VI-4 and VI-5. The B/C ratio for this project is 1.54. This ratio indicates that the project is economically feasible.

D. ENVIRONMENTAL OVERVIEW

1. Overview

Cooney Reservoir is located on Red Lodge Creek in the Yellowstone River Basin in south central Montana. It is situated in a sagebrush-grassland area of low, rolling hills. The project is operated and maintained by the Rock Creek Water Users Association. During winter months, the project is operated to maintain the water surface near elevation 4,230 feet. The reservoir is located near Billings and is used extensively for recreation. The reservoir has the third highest recreational use in the State of Montana (Markesan, pers. commun., 1982). The dam was rehabilitated in early 1982 for safety reasons.

The reservoir contains rainbow, brook, and brown trout. The Department of Fish, Wildlife and Parks stocks the reservoir with about 250,000 rainbow trout every year (Markesan, pers. commun., 1982). The bottom of the reservoir is smooth, compacted sediment that provides poor habitat for fish. The reservoir also provides some waterfowl habitat and bald eagles are known to inhabit the area. Peregrine falcon could potentially use the area as well.

The water quality in the reservoir is less than desirable owing to contamination by silt and feed-lot waste from upstream areas, although no fish kills have been reported (Markesan, pers. commun., 1982). The Department has been monitoring sedimentation in the reservoir and conducted a brief study of the problem in 1981. When soundings taken in the early 1970's were compared with the original bottom contours, it was estimated that sediment volume had increased by 10 to 12 percent (Brown, pers. commun., 1982). The reservoir is designed such that most of the sediment flows through in suspension and thus the rate of infilling is relatively slow.

The Water Quality Bureau of the Montana Department of Health and Environmental Sciences classifies the river as B-1. Dissolved oxygen and temperature standards for this classification are presented in Table VI-6. Red Lodge Creek below the dam contains some rainbow trout. The banks of the creek are susceptible to excessive erosion causing problems for owners of adjacent lands.

The Montana Historical Society has identified eight prehistoric and one historic site around Cooney reservoir. During the recent rehabilitation of the dam, monitoring was required to protect these resources.

2. Potential Problems

The environmental characteristics of the site suggest that potential problems would be minimal. In this study, it was assumed that historical outflows would be maintained, the elevation of the intake for the outlet works would not change, and that most of the spilled flow would be diverted through the power plant. This latter change may cause a slight reduction in the concentration of dissolved oxygen in the discharge water, but should not affect the value of the fishery habitat below the dam. Temperature of the discharge water may differ slightly from that of receiving water, but should still meet the established water quality standards. Water levels in the reservoir and downstream should not vary from what has been experienced in the past.

High recreational use of the reservoir requires that the project be designed to blend into the landscape as much as possible and to minimize interference with recreationists. Construction activities should be scheduled for times when people do not frequent the area.

The problem of streambank erosion in Red Lodge Creek warrants the development of a detailed plan for control of sediment while the project is being constructed. Minimum flows below the dam will probably be required as well.

Because water quality in the reservoir is less than pristine, ice cover during winter months can lead to reduced concentrations of dissolved oxygen in the water. No information is available regarding dissolved oxygen concentrations in the reservoir. Although the proposed project will not influence this concentration during winter months, the Water Quality Bureau might require the project to meet the dissolved oxygen standard of 7 mg/l in Red Lodge Creek. Insufficient information is available to determine whether the project could meet this standard.

The transmission line corridor is expected to be one mile or less and thus should have no major affect on fish or wildlife habitat. The area is rich in cultural resources, however, and a survey of the route may be required before an exemption application can be filed.

3. Recommended Action

a. Dissolved Oxygen

The DNRC should collect data regarding dissolved oxygen concentrations in the reservoir to define whether a potential problem exists. The DNRC should also enter into discussions with the Water Quality Bureau to determine what standards may be required for the discharge waters at the power plant.

b. Archeologic Survey

The DNRC should consult with the State Historic Preservation Officer to determine if an archeologic survey is

warranted or required. The survey should be conducted to identify any cultural or historical resources affected and to determine what mitigation measures might be desirable.

E. CONCLUSIONS AND RECOMMENDATIONS

A hydroelectric project at Cooney Dam is technically and economically feasible. If the proposed project was brought on-line by 1986, the cash flow for the plant would probably be negative for the first two years of operation. The project is recommended for development before 1990. Steps to monitor water quality and other environmental concerns should be initiated at an early date.

TABLE VI-1

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF PHYSICAL FEATURES
COONEY DAM HYDROELECTRIC PROJECT

Turbine Type:	Horizontal Francis
Turbine Capacity:	800(two 400 kW units)
Rated Head:	75 ft
Rated Flow:	75 cfs per unit
Average Annual Energy:	4.5 GWh

TABLE VI-2

MONTANA HYDROELECTRIC RECONNAISSANCE
PROJECT CAPITAL COSTS
COONEY DAM HYDROELECTRIC PROJECT

	Item	Cost
1.	Structures and Improvements	$ 251,200
2.	Reservoirs, Dams, and Waterways	383,000
3.	Turbines and Generators	405,000
4.	Accessory Electrical Equipment	100,000
5.	Miscellaneous Mechanical Equipment	15,000
6.	Switchyard	20,000
7.	Transmission Lines	30,000
	Direct Construction Cost	1,204,200
	Contingencies	214,800
	Subtotal	1,419,000
	Engineering (25%)	354,800
	Subtotal	1,773,800
	Administrative, Legal, and Financial (5%)	88,700
	Subtotal	1,862,500
	Interest During Construction	335,300
	TOTAL PROJECT CAPITAL COST (July, 1982)	$2,197,800
	TOTAL PROJECT CAPITAL COST (Escalated to July 1984 at 8% compounded annually)	$2,563,500

TABLE VI-3

ESTIMATED ANNUAL COST

COONEY DAM HYDROELECTRIC PROJECT

1.	Total Project Capital Cost escalated to July, 1984		$2,563,500
2.	Estimated Cost of Capital:	12%	
3.	Economic Life of Project:	50 Years	
4.	Annual Costs		
	4.1 Amortization Cost 1/		313,500
	4.2 O, M & R 2/		20,700
			$ 334,200
5.	Estimated Average Annual Generation		
	4,520,000 kWh/Annum		
6.	Unit Cost of Power 3/		

$$\frac{\$\ 334,200}{4,520,000} \times 1,000 = 73.9 \text{ mills/kWh}$$

1/ Amortized for 35 years at 12 percent.

2/ 1.25 percent of Capital Cost plus contingency, escalated to July, 1984.

3/ First year of operation (1986).

TABLE VI-4

Benefit/Cost Analysis - Tudor Engineering Company

COONEY DAM HYDROELECTRIC PROJECT - STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

JULY 1982

Year	Cost Streams		Benefit Stream (*)	Present Worth Factor (*)	Present Worths	
	Debt Service	OM&R (*)			Cost	Benefit
1986	313500	20700	298300	1.00000	334200	298300
1987	313500	22400	328100	0.89286	299900	293000
1988	313500	24100	360900	0.79719	269200	287700
1989	313500	26100	397000	0.71178	241700	282600
1990	313500	28200	436700	0.63552	217100	277600
1991	313500	30400	480400	0.56743	195100	272600
1992	313500	32800	528500	0.50663	175500	267700
1993	313500	35500	581300	0.45235	157900	263000
1994	313500	38300	639400	0.40388	142100	258300
1995	313500	41400	703400	0.36061	128000	253600
1996	313500	41400	703400	0.32197	114300	226500
1997	313500	41400	703400	0.28748	102000	202200
1998	313500	41400	703400	0.25668	91100	180500
1999	313500	41400	703400	0.22917	81300	161200
2000	313500	41400	703400	0.20462	72600	143900
2001	313500	41400	703400	0.18270	64800	128500
2002	313500	41400	703400	0.16312	57900	114700
2003	313500	41400	703400	0.14564	51700	102400
2004	313500	41400	703400	0.13004	46100	91500
2005	313500	41400	703400	0.11611	41200	81700
2006	313500	41400	703400	0.10367	36800	72900
2007	313500	41400	703400	0.09256	32800	65100
2008	313500	41400	703400	0.08264	29300	58100
2009	313500	41400	703400	0.07379	26200	51900
2010	313500	41400	703400	0.06588	23400	46300
2011	313500	41400	703400	0.05882	20900	41400
2012	313500	41400	703400	0.05252	18600	36900
2013	313500	41400	703400	0.04689	16600	33000
2014	313500	41400	703400	0.04187	14900	29400
2015	313500	41400	703400	0.03738	13300	26300
2016	313500	41400	703400	0.03338	11800	23500
2017	313500	41400	703400	0.02980	10600	21000
2018	313500	41400	703400	0.02661	9400	18700
2019	313500	41400	703400	0.02376	8400	16700
2020	313500	41400	703400	0.02121	7500	14900
2021	0	41400	703400	0.01894	800	13300
2022	0	41400	703400	0.01691	700	11900
2023	0	41400	703400	0.01510	600	10600
2024	0	41400	703400	0.01348	600	9500
2025	0	41400	703400	0.01204	500	8500
2026	0	41400	703400	0.01075	400	7600
2027	0	41400	703400	0.00960	400	6700
2028	0	41400	703400	0.00857	400	6000
2029	0	41400	703400	0.00765	300	5400
2030	0	41400	703400	0.00683	300	4800
2031	0	41400	703400	0.00610	300	4300
2032	0	41400	703400	0.00544	200	3800
2033	0	41400	703400	0.00486	200	3400
2034	0	41400	703400	0.00434	200	3100
2035	0	41400	703400	0.00388	200	2700
				Totals	3170300	4845300

Benefit/Cost Ratio = 4845300/3170300 = 1.53

* Note:

OM&R Escalation Rate = 8 % for years 1 - 10
OM&R Escalation Rate = 0 % for years 11 - 50

Power Revenue Escalation Rate = 10 % for years 1 - 10
Power Revenue Escalation Rate = 0 % for years 11 - 50

Discount Rate = 12 % for years 1 - 50

TABLE VI-5

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF ECONOMIC FEATURES
COONEY DAM HYDROELECTRIC PROJECT

Interest Rate:	12%
Total Project Cost: 1/	$2,563,500
Annual Debt Service:	313,500
Annual Operation and Maintenance:	20,700
Total Annual Cost:	334,200
Production Cost, Mills/kWh:	73.9
Production Cost, $/kW:	3,204
Power Value, Mills/kWh: 2/	66
Benefit/Cost Ratio:	1.53

1/ July 1984.
2/ July 1986.

TABLE VI-6

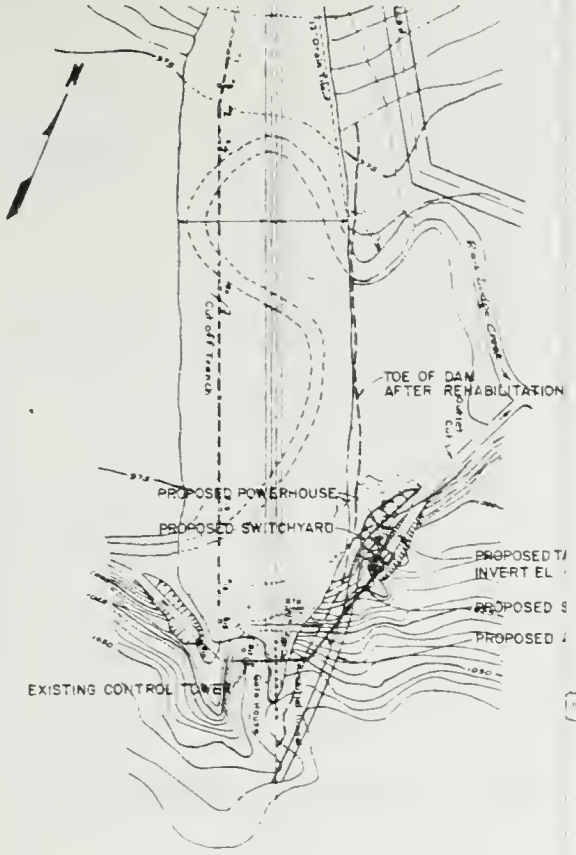
DISSOLVED OXYGEN AND TEMPERATURE STANDARDS

COONEY RESERVOIR

COONEY DAM HYDROELECTRIC PROJECT

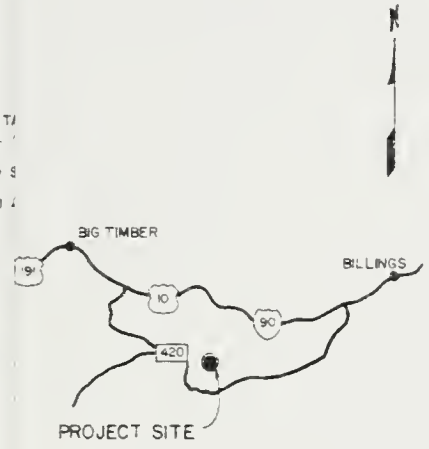
Parameter	Standard
Dissolved Oxygen	- Cannot fall below 7 mg/ .
Temperature	- No more than 1 degree increase when the water temperature is 32 to 36°F.
	- Cannot exceed 67°F when the water temperature is 66 to 66.5°F.
	- No more than a 0.5 degree increase when water temperature is above 66.5°F.
	- No more than a 2 degree decrease per hour when the water temperature is above 55°F.
	- Cannot decrease more than 2 degrees when the water temperature is 55 to 32°F.

Source: Horpestad, pers. commun., 1982.

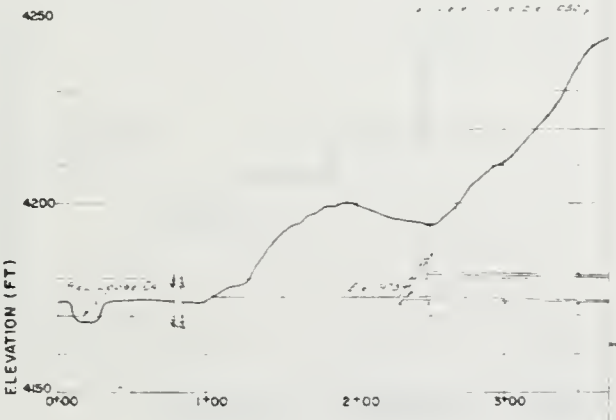


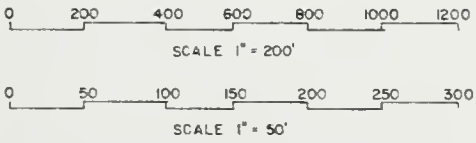
GENERAL PLAN
SCALE 1" = 200'

LOCATION MAP



VICINITY MAP





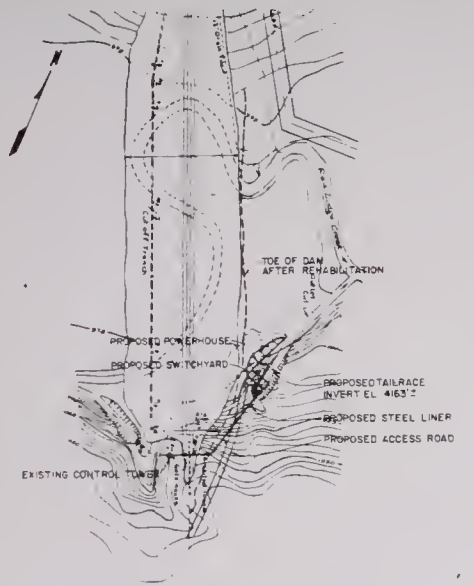
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

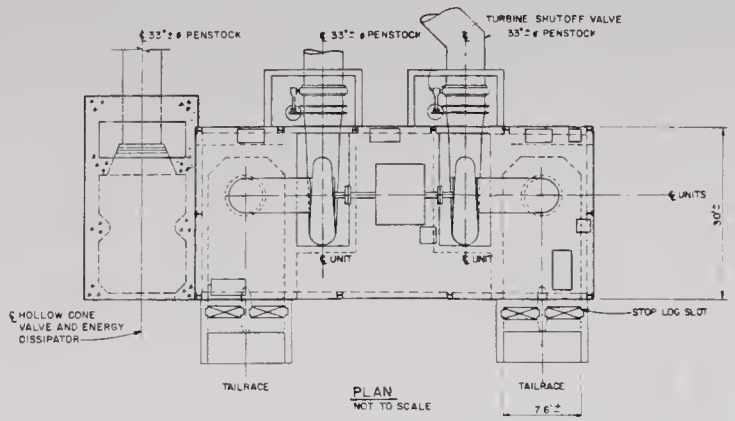
COONEY DAM HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

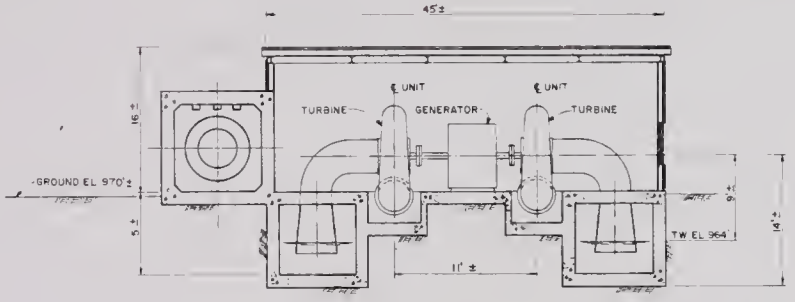
FIGURE VI-1



GENERAL PLAN
SCALE 1" = 200'

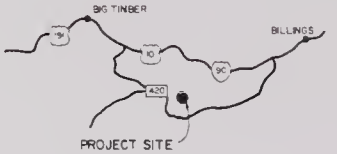


PLAN
NOT TO SCALE



SECTION ALONG CENTERLINE OF POWERHOUSE
NOT TO SCALE

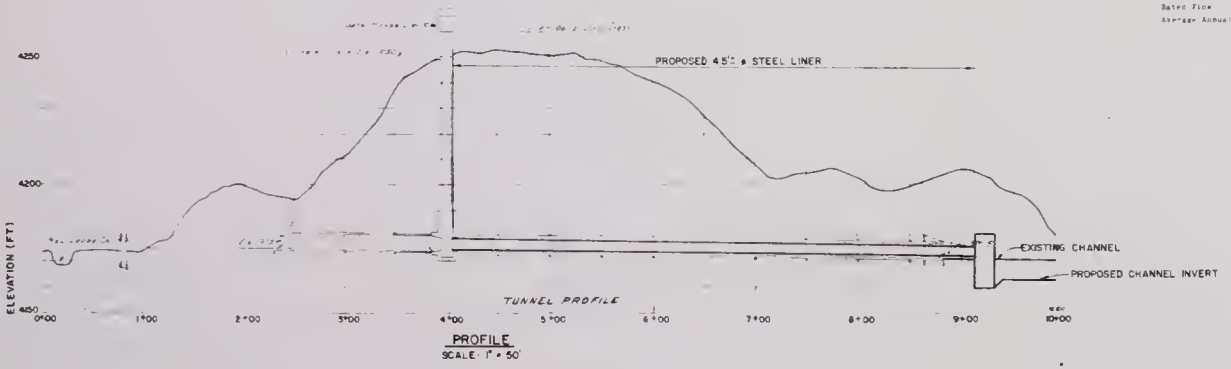
LOCATION MAP



VICINITY MAP

PROJECT DATA
COONEY DAM HYDROELECTRIC PROJECT

Turbine Type	Horizontal Francis
Turbine Capacity	400± kW (2 units)
Rated Head	75 ft
Rated Flow	75 cfs per unit
Average Annual Energy	4.5 GWh



PROFILE
SCALE: 1" = 50'

0 200 400 600 800 1000 1200
SCALE 1" = 200'

0 50 100 150 200 250 300
SCALE 1" = 50'

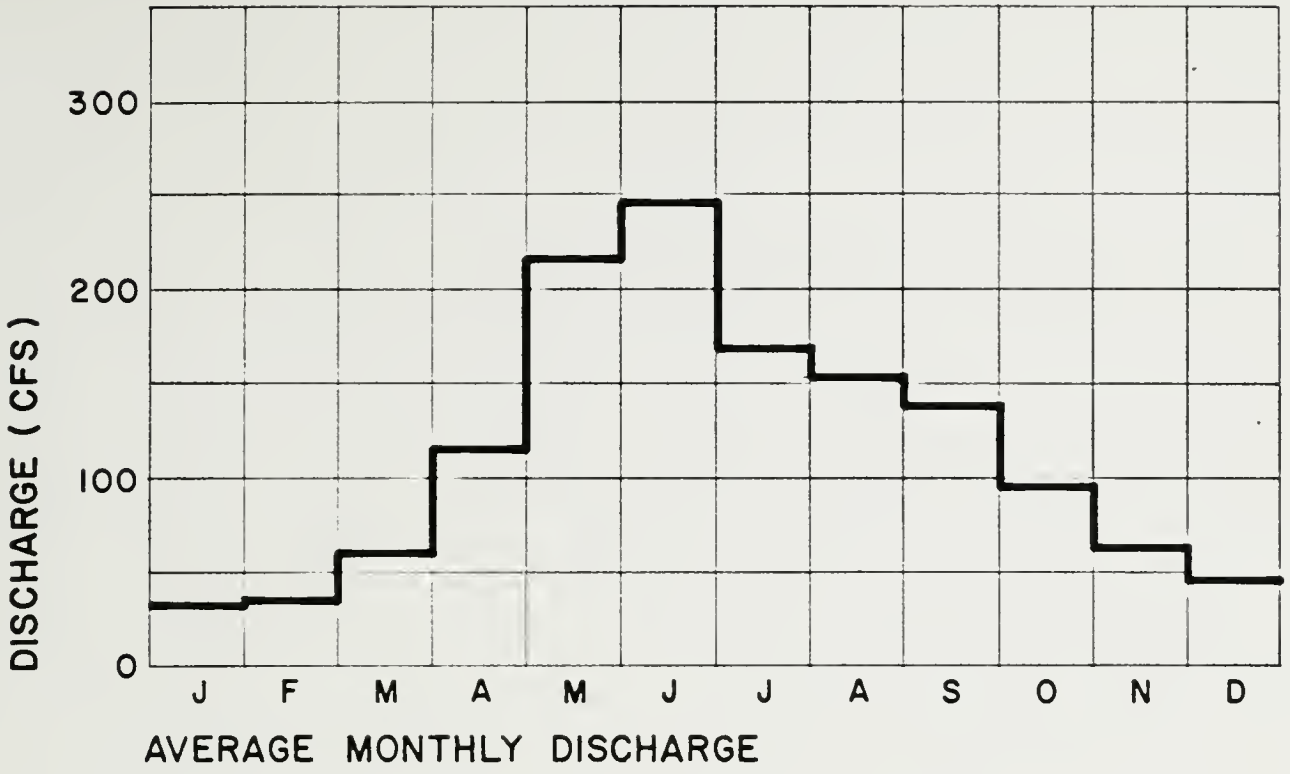
NOTE
DAM CREST EL 1060' (DNR & C DATUM) = EL 4260 MSL

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

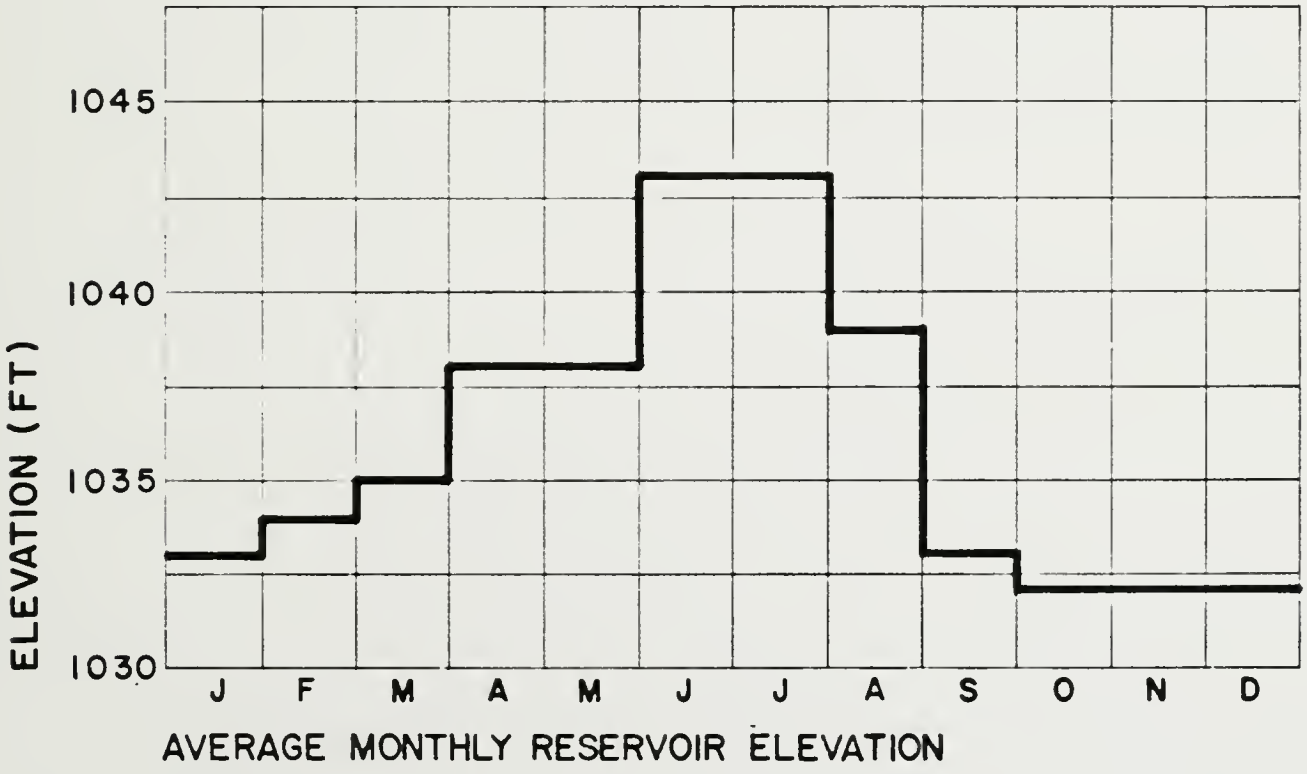
MONTANA HYDROELECTRIC RECONNAISSANCE
COONEY DAM HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY — SAN FRANCISCO, CALIFORNIA

FIGURE VI-1



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

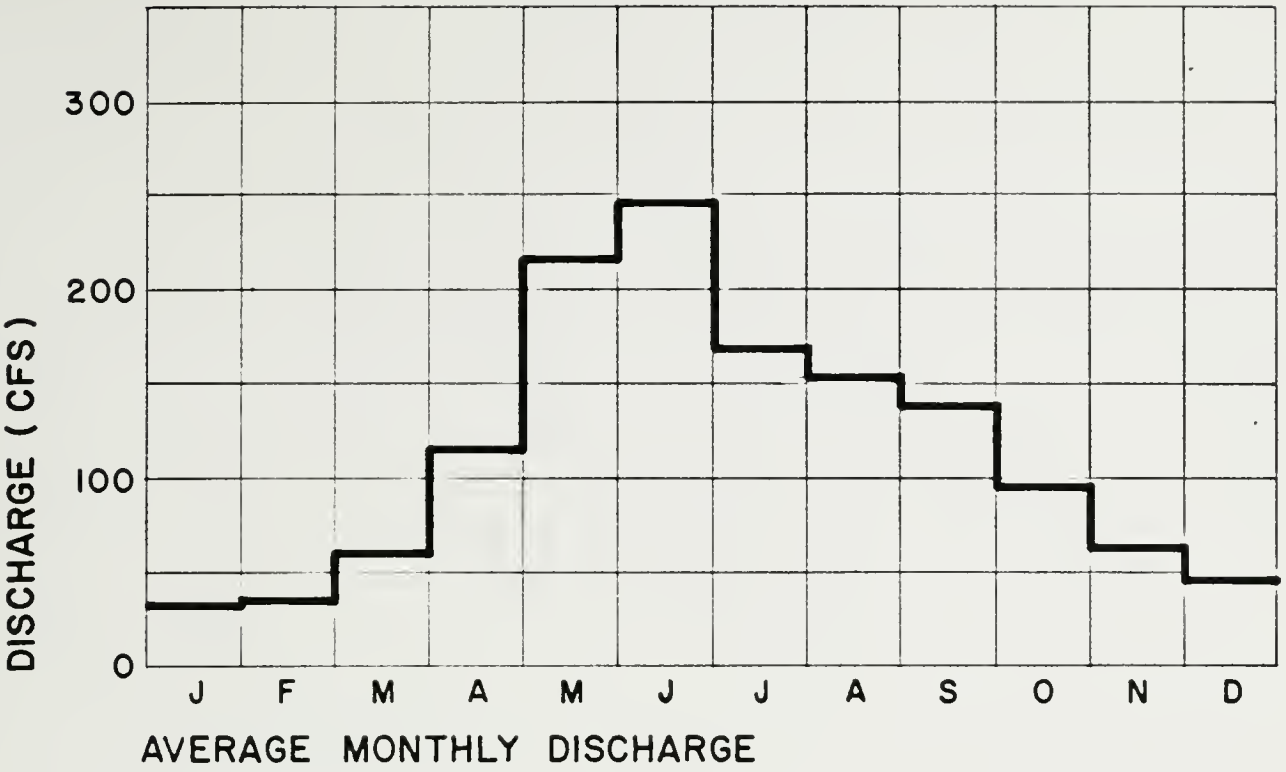
STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

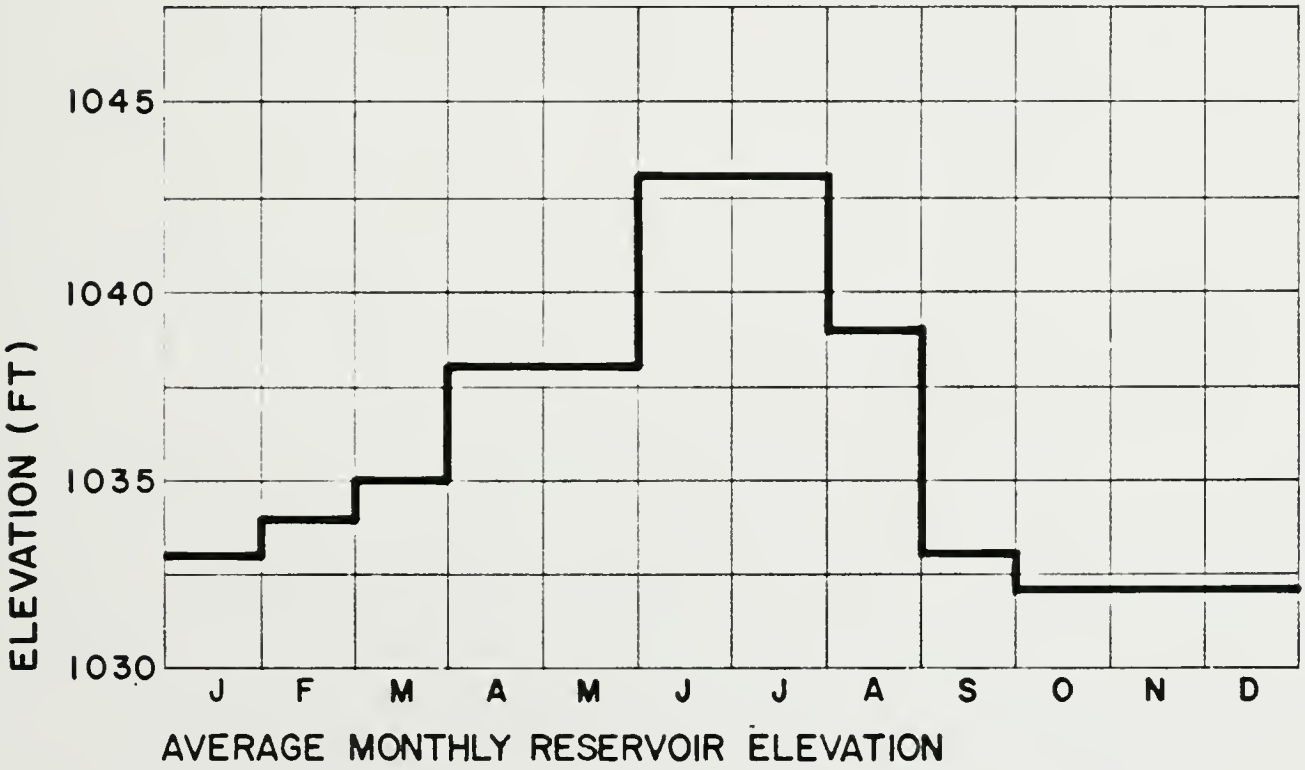
COONEY DAM

FIGURE

VI-2



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

COONEY DAM

FIGURE

VI-2

TONGUE RIVER DAM AND RESERVOIR

TONGUE RIVER DAM SPILLWAY AND OUTLET WORKS

SECTION VII

TONGUE RIVER HYDROELECTRIC PROJECT

A. GENERAL

The Tongue River Hydroelectric Project would be located at the Tongue River Dam, an earthfill structure on the Tongue River approximately ten miles north of the Montana-Wyoming state line. The dam is in Big Horn County near the town of Decker. The reservoir impounded by the dam is used primarily for irrigation storage; however, recreational and industrial uses are also benefits associated with the existing project. The proposed project would utilize flow releases through the dam outlet works to produce approximately 11.5 million kilowatt-hours of electrical energy annually.

B. EXISTING FACILITIES

The main features of the Tongue River Project are the dam, reservoir, spillway, and outlet works. Additional existing features significant to the development of a hydroelectric project include access to the site and the existence of electrical transmission lines. The existing facilities are described in more detail below. The arrangement of the facilities is shown on Figure VII-1.

1. Dam

The Tongue River Dam is a zoned earthfill embankment with a maximum structural height of 91 feet and a crest length of 1,824 feet at elevation 3,148 feet. The dam has a crest width of 54.5 feet and was placed on a slope of 3:1 on the upstream face and 2.25:1 on the downstream face.

The spillway and outlet works are located at the left abutment of the dam (looking downstream). The spillway drops about 70 feet over a distance of about 563 feet. The spillway crest elevation is 3,130 feet. The spillway is 350 feet wide at the crest and tapers to about 100 feet in width at the stilling basin. Wave formation is a serious problem at high discharges and the Dam Safety Report (1980) indicates that the spillway would not pass the probable maximum flood.

The outlet works intake is to the right of the spillway just upstream from the dam. An approach channel at elevation 3,060 feet delivers flow from the bottom of the reservoir to a box type intake structure with trash racks. The flow is discharged through a 16 foot diameter horseshoe tunnel. The total length of the tunnel is about 750 feet; of this total, 230 feet are upstream from the outlet control gates and are pressurized, and 520 feet are downstream from the control gates and operate under open channel flow conditions. The tunnel discharges to the stilling basin at the center of the spillway at elevation 3,059.5. The Dam Safety Report indicates that extensive cavitation damage to the control works and tunnel has occurred as the result of passing flood flows through the outlet works. The report recommends that the discharge through the outlet works be limited to what can be safely passed.

The description presented above reflects the existing conditions at the dam. For purposes of this report, no attempt has been made to determine the effects of modification of the facilities in response to the Dam Safety Report. It has been indicated that the existing spillway will probably be abandoned (Bondy, pers. comm., 1982).

2. Site Access

Existing dirt roads currently provide access to the crest of the dam and to both sides of the spillway. These roads

would provide adequate access to the powerhouse location for construction, operation, and maintenance of the project.

3. Transmission Lines

During the June 5, 1982 field trip to the Tongue River site, transmission lines were observed within 500 feet of the proposed powerhouse location. It is anticipated that transmission lines with adequate capacity for the transmission of power from the Tongue River Project exist in the immediate area of the project. The project is in the Montana Power Company service area. In additon to lines owned by Montana Power Company, a major transmission line owned by Pacific Power and Light Company passes within 20 miles of the project site. For purposes of estimating the project cost, it has been assumed that it will be necessary to construct approximately one mile of new transmission lines.

The location and nature of the connnection to an existing grid would need to be determined as part of a detailed feasibility study. Costs associated with transmission lines could include construction of new lines or reconductoring of existing lines. The limited data obtained during this study were not adequate to make this determination.

C. PROPOSED PROJECT

Several alternative layouts were considered for the Tongue River site. Included in the layouts were alternatives that would require modification of the spillway and the construction of a new intake and tunnel. These alternatives were eliminated because of cost considerations and technical problems associated with construction; however, all potential schemes should be examined as part of a detailed feasibility study of the site. A description of the alternative selected for this site is presented below.

1. Project Description

The proposed Tongue River Hydroelectric Project would consist of a penstock, a tunnel, and a powerhouse, in addition to miscellaneous project features such as a hollow cone, low flow bypass and pressure regulation valve, a switchyard, and an access road and transmission lines. The layout proposed for this project would maintain as much of the existing outlet works hydraulic capacity as possible, as requested by the Department (Bondy, pers. comm., 1982). The Dam Safety Report (1982) indicates that it is not advisable to pass extremely high flows through the outlet works because of cavitation damage. The Department has indicated that the existing spillway will be abandoned because of unfavorable hydraulic characteristics. Both the hydraulic capacity of the outlet works and the location of the powerhouse relative to the spillway should be evaluated in detail as part of a feasibility study of the proposed project. The project described below is presented entirely for the purpose of proving the technical and economic feasibility of the proposed development.

A 9.5 foot diameter hollow cone valve would be installed downstream from the existing gate house. This valve would have a hydraulic capacity of 4,300 cfs at 88 feet of head, which is approximately equal to the existing outlet capacity (Dam Safety Report, 1982). A steel penstock with a reducing section would be welded to the existing 12-foot diameter steel liner. Between the existing 12-foot diameter steel liner and the hollow cone valve, a seven-foot diameter steel penstock would bifurcate from the reducing section. This penstock would pass directly beneath the hollow cone valve and would be buried in the bottom of the 16-foot diameter horseshoe tunnel. The penstock would be encased in concrete to prevent corrosion due to galvanic action. About 300 feet downstream from the gate house, the penstock would bend downstream, parallel to the

centerline of the spillway, and enter a new 10-foot diameter horseshoe tunnel. This tunnel and penstock would deliver the flow to the powerhouse, which would be to the right of the spillway stilling basin. The powerhouse would contain a single, tubular type turbine and would discharge to the spillway stilling basin. The significant physical features of the project are summarized as Table VII-1, and are shown graphically as Figure VII-1.

2. Hydrology and Hydraulics

The Tongue River is a tributary of the Yellowstone River, which is part of the Missouri River system. The Tongue River Dam is located at river mile 162.8, seven miles northeast of Decker, Montana, and four miles upstream from Post Creek. The United States Geological Survey (USGS) maintains a stream gage on the river below the dam and a reservoir level gage upstream from the dam.

The discharge downstream from the dam is recorded by USGS stream gage 06307500, "Tongue River at Tongue River Dam, near Decker, MT" The total drainage area above the site is 1,770 square miles. Records are available from May 1939 to the current year. The flow upstream from the gage is regulated by Tongue River Reservoir and a number of other small reservoirs and there are numerous upstream diversions for agricultural and industrial uses. The maximum and minimum discharges over the period of record were 7,340 cfs on June 15 or 16, 1967 and no flow for part of each day, November 12 and 13, 1969, respectively. The average discharge over the period 1940-1976 was 461 cfs.

The water surface level in the reservoir is recorded by USGS stream gage 06307000, "Tongue River Reservoir". Records have been maintained for this reservoir since December 1938. The maximum observed reservoir contents were 79,600 AF on May

20, 1978. The total storage available in the reservoir is 69,439 AF at the spillway crest elevation of 3,130 feet. Of this total, 1,400 AF are below the intake invert elevation of 3,374.4 feet.

The water surface elevation downstream from the outlet works varies from elevation 3,060 feet at zero discharge to elevation 3,065 feet at a discharge of 2,000 cfs.

For purposes of estimating installed capacities, power production and energy production, the historical records of flows and reservoir elevations for the calendar years 1964 through 1973 were used to develop an annual hydrograph of average monthly flows, and an average monthly record of water surface elevations. These values are shown graphically on Figure VII-2. The average annual flow for this period of time was 543 cfs. This amount is 18 percent greater than the long-term average of 461 cfs and indicates that the flows used for the calculation of power production may have been somewhat high; however, inspection of the flow records indicate that the effect of this overestimation should be negligible. The difference in average flow values for the two periods occurs primarily during the period of May, June, and July, when the average flows are greater than the turbine rated flow of 575 cfs. If only the flows that the turbine would accept are considered (i.e., flows greater than 575 cfs equal 575 cfs) the long-term average would be 344 cfs, compared to 374 cfs for the period of study. These values are within 10 percent of each other, indicating that the hydrograph selected for the study is representative of current demands and the long-term average.

3. Power Study

The average annual hydrograph and average record of monthly water surface elevations described above were used to estimate the installed capacity and annual average energy production for

the Tongue River Project. This determination was made based on typical turbine performance characteristics and the physical characteristics of the site. The head available for power production was estimated as the difference between the headwater and tailwater elevation minus an allowance for head losses. The capacity of the plant was not optimized; however, an attempt was made to select the turbine so that its operation would encompass a wide range of head and flow.

A tubular type turbine with a rated head of 55 feet, rated flow of 550 cfs, and rated capacity of 2,175 kilowatts was selected for the Tongue River site. This unit was selected because it is a standardized unit that should be less costly than a custom-made unit and would produce a comparable amount of energy to other types of units that could be installed at this site. Standard tube units are available for heads up to about 60 feet. The turbine would produce power year-round during an average year and would produce approximately 11.5 million kilowatt-hours annually. The average annual plant factor for the site would be about 61 percent. The physical features of the project are summarized as Table VII-1.

4. Cost Estimate

The total project capital cost consists of the direct construction cost; the associated indirect costs for engineering, management and administration; and interest during construction. The cost estimate for the Tongue River Project is presented as Table VII-2. This cost does not include any costs related to corrective measures associated with dam safety. This cost estimate is based on bid prices for similar construction work, recent manufacturers quotes for mehcanical and electrical equipment, and experience with other projects. The estimate also includes allowances for contingencies and for the costs of engineering. The contingency allowance is 15 percent of the mechanical and electrical costs plus 20 percent of all

other costs. The engineering costs cover activities which include detailed feasibility studies, obtaining miscellaneous licenses and permits, final design, contract plans and specifications, and engineering services during construction. This amount was estimated as 25 percent of the direct construction cost plus contingencies. An allowance was also made for owner administration, financial, and legal expenses. Interest during construction was based on an 18-month construction period and 12 percent interest.

The cost estimate is presented at July 1982 price levels. The estimated total project capital cost for the Tongue River Project is $5,094,100. If this cost is escalated to the proposed project bid date of July 1984 at eight percent annual inflation, the cost would be $5,941,800. The cost estimate for the Tongue River Project is summarized as Table VII-2.

5. Economic Analysis

The benefits and costs associated with the Tongue River Hydroelectric Project were assessed in order to determine the overall economic feasibility of the project. The project capital cost was escalated to July, 1984, at eight percent annual escalation; this is the proposed bid date for the project. The value of power was escalated at ten percent annual interest to Janaury 1986, the proposed on-line date for the project. The difference in the rate of escalation of construction and energy costs reflects an apparent trend of energy costs to escalate at a rate more rapid than general inflation. It was assumed that the project would be financed with bonds having a life of 35 years and bearing a 12 percent interest rate. The cost of operation and maintenance for the first year of operation would be 1.25 percent of the capital cost plus contingencies. The annual costs of the Tongue River Project are summarized on Table VI-3.

It was assumed that the rate of general inflation is eight percent and that energy would escalate at ten percent annually. Inflation was considered for 10 years beyond the proposed on-line date of January 1986 and then held constant. All costs were discounted to January 1986 at 12 percent annual interest and the present worth of the benefits was compared to the present worth of costs to produce a benefit/cost (B/C) ratio for the project. The B/C calculation and a summary of economic features are presented as Tables VII-4 and VII-5. The B/C ratio for this project is 1.68. This ratio indicates that the project is economically feasible.

D. ENVIRONMENTAL OVERVIEW

1. Overview

Tongue River Reservoir is located in the Yellowstone River Basin in southeastern Montana. It is situated in an area of low, rolling hills covered with sagebrush. The normal water surface elevation is at the spillway crest, 3424 feet. A large coal mine is located near the upper end of the reservoir. In 1976, repairs were made to the outlet tunnel. A 1978 flood weakened the dam and DNRC is planning to rehabilitate it. DNRC is beginning studies of minimum flow needs in the river and archaeological resources before proceeding with the project (Brasch, pers. commun., 1982).

The reservoir supports a good population of walleye and northern pike. The Department of Fish, Wildlife and Parks has developed a spawning marsh in the upper end of the reservoir that has helped sustain a wild fishery there, although walleye are stocked periodically. The reservoir stratifies when ice covers it in winter. As a result of this condition, minor fish kills have been observed at times during winter months. Some distressed fish have also been observed below the outlet works and in the river below the dam (Elser, pers. commun., 1982).

Because of the weakened dam, the reservoir is lowered drastically in the fall to store sufficient flood waters in the spring. The lowered reservoir pool has actually increased growth rates of walleye and northern pike, although the long-term effects on the fish are unknown. Low pool levels probably have adverse effects during spawning season. The DNRC is planning to rehabilitate the dam, which should stabilize water management there (Elser, pers. commun., 1982).

Some of the larger northern pike and walleye have been found to contain levels of mercury that exceed FDA standards, although a significant percentage of the population is not affected (Phillips, pers. commun., 1982). The mercury is suspected to originate from the underlying bedrock and concentrates primarily in the sediment. Bacteria convert the element to methyl mercury that is then taken up by fish from the water or through the food chain. Concentrations in the water are normally below detectable levels.

The Tongue River is classified as B-2 by the Water Quality Bureau of the Montana Department of Health and Environmental Sciences. The standards for dissolved oxygen and temperature for this classification are presented in Table VII-6. Water quality data were obtained from STORET for USGS gage no. 06307500 on the Tongue River at Tongue River Dam. Data on dissolved oxygen were available from 1975 to 1982. The mean concentration for the period of record was 10.3 mg/l with an average saturation of 101 percent. The standard deviation is 2.0 mg/l. Over the six years of record, the minimum level of dissolved oxygen was 6.6 mg/l with a saturation of 83 percent, while the maximum was 14.8 mg/l and 141 percent saturation. Dissolved solids averaged 444 mg/l over the same time frame. Mercury was sampled in the water from 1979 to 1981. The combined concentration for dissolved and suspended levels of mercury amounted to an average of 0.075 micrograms per liter.

The lower 20 miles of the Tongue River provides spawning habitat for sauger, sturgeon, and channel catfish in the months of April through June. The Department of Fish, Wildlife, and Parks has acquired a reserved flow of 75 cfs to support spawning, but intends to negotiate higher flows when the dam is rehabilitated. At present, the Department believes that 300 cfs in April and early May are necessary for sauger and 500 cfs in late May and June for sturgeon (Elser, pers. commun., 1982).

Waterfowl use is significant on the river, especially during the migration periods of March-April and October to early December. Canada geese and ducks are common. Some waterfowl production also takes place on the reservoir with blue herons and cormorants nesting in the upper end of the reservoir.

2. Potential Problems

The environmental characteristics of the site suggest that potential problems will be minimal. In this study, it was assumed that historical outflows will be maintained, the elevation of the intake for the outlet works would not change, and that most of the spilled flow will be diverted through the power plant. This latter change will mainly influence dissolved oxygen in the discharge water. Temperature in the discharge water may differ slightly from that of the receiving water, but should still meet the established water quality standards. Water levels in the reservoir and downstream should not vary from what has been experienced in the past. Retention time, which affects concentrations of mercury in fish, will also remain unchanged.

Water diverted from the spillway to the power plant gains no dissolved oxygen through reaeration. In concentrations that are already marginal for sustaining the fishery, the loss of

this small addition of oxygen could reduce the concentration of dissolved oxygen to toxic levles. Some minor fish kills have been observed in the reservoir and near the outlet work during winter moths when ice cover causes the reservoir to stratify. This suggests that dissolved oxygen cocnentrations do fall below 5 mg/l at times. The Water Quality Bureau might require the project to meet the dissolved oxygen standard for winter months of 7 mg/l in the Tongue River.

The reservoir is located in an area rich in Indian culture and archaeologic resources. An archaeologic survey is being conducted at present in anticipation of rehabilitating the dam and raising its water level. This survey may be adequate for the project site, but would not include the transmission line corridor. A survey of this corridor may be required before an exemption application can be filed.

3. Recommended Action

a. Dissolved Oxygen. The DNRC should better define the dissolved oxygen problem in the reservoir by determining the frequency, duration, and magnitude of episodes when the concentration drops below 7 mg/l in the winter. The DNRC should also enter into discussions with the Water Quality Bureau to determine what standards may be required for the discharge waters at the power plant.

b. Archaelogic Survey. The DNRC should consult with the State Historic Preservation Officer to determine if an archaeologic survey is warranted or required. The survey should be conducted to identify any cultural or historical resources along the route and to determine what mitigation measures might be desirable.

E. CONCLUSIONS AND RECOMMENDATIONS

The Tongue River Project is a technically, economically, and environmentally viable project and its immediate implementation is recommended. A detailed feasibility study should be conducted, and an Application for Exemption should be submitted to the Federal Energy Regulatory Commission.

TABLE VII-1

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF PHYSICAL FEATURES
TONGUE RIVER HYDROELECTRIC PROJECT

Turbine Type:	Tubular
Turbine Capacity:	2,175 kW (one unit)
Rated Head:	55 ft
Rated Flow:	550 cfs
Average Annual Energy:	11.5 GWh

TABLE VII-2

MONTANA HYDROELECTRIC RECONNAISSANCE
PROJECT CAPITAL COSTS
TONGUE RIVER HYDROELECTRIC PROJECT

	Item	Cost
1.	Structures and Improvements	$ 242,900
2.	Reservoirs, Dams, and Waterways	1,302,000
3.	Turbines and Generators	950,000
4.	Accessory Electrical Equipment	200,000
5.	Miscellaneous Mechanical Equipment	25,000
6.	Switchyard	40,000
7.	Transmission Lines	30,000
		2,789,900
	Direct Construction Cost	
	Contingencies (15% - Mech. & Elec. 20% - All Other)	499,200
	Subtotal	3,289,100
	Engineering (25%)	822,300
	Subtotal	4,111,400
	Administrative, Legal, and Financial (5%)	205,600
	Subtotal	4,317,000
	Interest During Construction	777,100
	TOTAL PROJECT CAPITAL COST (July 1982)	5,094,100
	TOTAL PROJECT CAPITAL COST (Escalated to July 1984 at 8% annual inflation)	5,941,800

TABLE VII-3

ESTIMATED ANNUAL COST

TONGUE RIVER HYDROELECTRIC PROJECT

1.	Total Project Capital Cost escalated to July, 1984		$5,941,800
2.	Estimated Cost of Capital:	12%	
3.	Economic Life of Project:	50 Years	
4.	Annual Costs		
	4.1 Amortization Cost[1/]		$ 726,700
	4.2 O, M, & R[2/]		48,000
			774,700
5.	Estimated Average Annual Generation		
	11,500,000 kWh/Annum		
6.	Unit Cost of Power [3/]		

$$\frac{\$\ 774,700}{11,500,000} \times 1,000 = 67.4 \text{ mills/kWh}$$

1/ Amortized for 35 years at 12 percent.

2/ 1.25 percent of Capital Cost plus contingency, escalated July, 1984.

3/ First year of operation (1986).

TABLE VII-4

Benefit/Cost Analysis - Tudor Engineering Company

TONGUE RIVER HYDROELECTRIC PROJECT - STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

AUGUST 1982

Year	Cost Streams		Benefit Stream (*)	Present Worth Factor (*)	Present Worths	
	Debt Service	OM&R (*)			Cost	Benefit
1986	726700	48000	759000	1.00000	774700	759000
1987	726700	51800	834900	0.89286	695100	745400
1988	726700	56000	918400	0.79719	624000	732100
1989	726700	60500	1010200	0.71178	560300	719100
1990	726700	65300	1111300	0.63552	503300	706200
1991	726700	70500	1222400	0.56743	452400	693600
1992	726700	76200	1344600	0.50663	406800	681200
1993	726700	82300	1479100	0.45235	365900	669100
1994	726700	88800	1627000	0.40388	329400	657100
1995	726700	96000	1789700	0.36061	296700	645400
1996	726700	96000	1789700	0.32197	264900	576200
1997	726700	96000	1789700	0.28748	236500	514500
1998	726700	96000	1789700	0.25668	211200	459400
1999	726700	96000	1789700	0.22917	188500	410100
2000	726700	96000	1789700	0.20462	168300	366200
2001	726700	96000	1789700	0.18270	150300	327000
2002	726700	96000	1789700	0.16312	134200	291900
2003	726700	96000	1789700	0.14564	119800	260700
2004	726700	96000	1789700	0.13004	107000	232700
2005	726700	96000	1789700	0.11611	95500	207800
2006	726700	96000	1789700	0.10367	85300	185500
2007	726700	96000	1789700	0.09256	76100	165700
2008	726700	96000	1789700	0.08264	68000	147900
2009	726700	96000	1789700	0.07379	60700	132100
2010	726700	96000	1789700	0.06588	54200	117900
2011	726700	96000	1789700	0.05882	48400	105300
2012	726700	96000	1789700	0.05252	43200	94000
2013	726700	96000	1789700	0.04689	38600	83900
2014	726700	96000	1789700	0.04187	34400	74900
2015	726700	96000	1789700	0.03738	30800	66900
2016	726700	96000	1789700	0.03338	27500	59700
2017	726700	96000	1789700	0.02980	24500	53300
2018	726700	96000	1789700	0.02661	21900	47600
2019	726700	96000	1789700	0.02376	19500	42500
2020	726700	96000	1789700	0.02121	17500	38000
2021	0	96000	1789700	0.01894	1800	33900
2022	0	96000	1789700	0.01691	1600	30300
2023	0	96000	1789700	0.01510	1400	27000
2024	0	96000	1789700	0.01348	1300	24100
2025	0	96000	1789700	0.01204	1200	21500
2026	0	96000	1789700	0.01075	1000	19200
2027	0	96000	1789700	0.00960	900	17200
2028	0	96000	1789700	0.00857	800	15300
2029	0	96000	1789700	0.00765	700	13700
2030	0	96000	1789700	0.00683	700	12200
2031	0	96000	1789700	0.00610	600	10900
2032	0	96000	1789700	0.00544	500	9700
2033	0	96000	1789700	0.00486	500	8700
2034	0	96000	1789700	0.00434	400	7800
2035	0	96000	1789700	0.00388	400	6900
				Totals	7349100	12328600

Benefit/Cost Ratio = 12328600/7349100 = 1.68

* Note:

OM&R Escalation Rate = 8 % for years 1 - 10
OM&R Escalation Rate = 0 % for years 11 - 50

Power Revenue Escalation Rate = 10 % for years 1 - 10
Power Revenue Escalation Rate = 0 % for years 11 - 50

Discount Rate = 12 % for years 1 - 50

TABLE VII-5

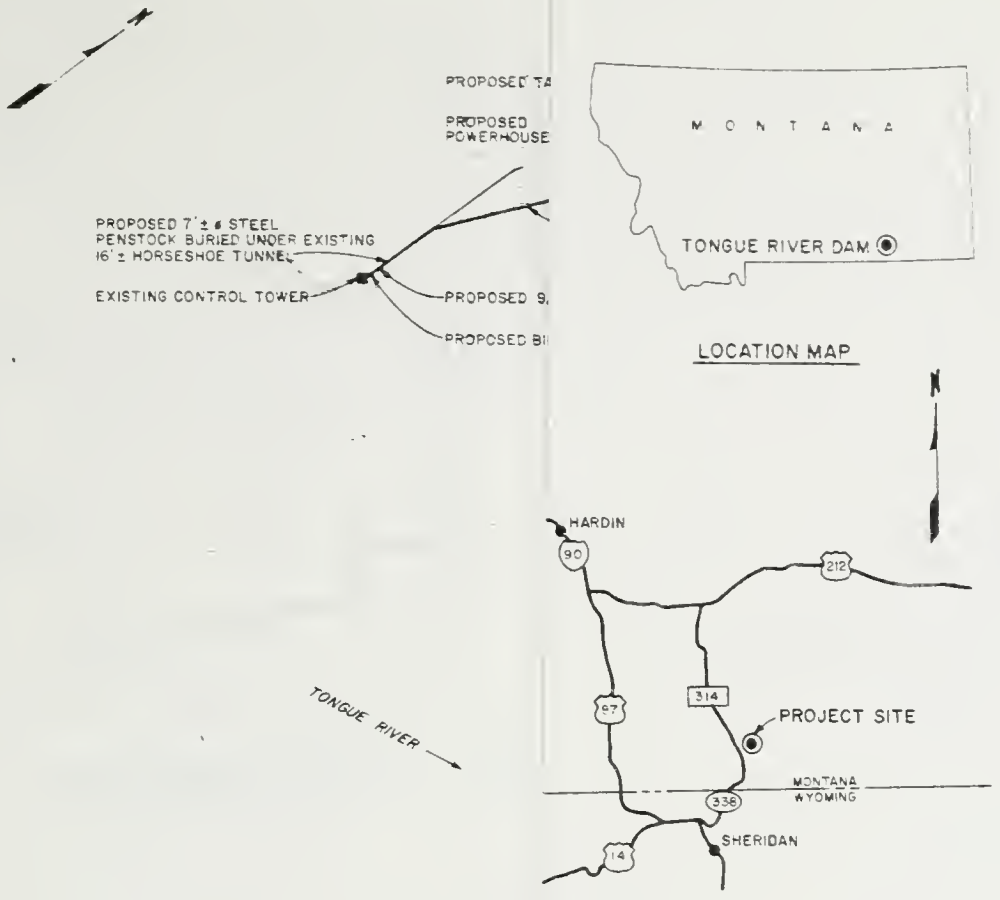
MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF ECONOMIC FEATURES
TONGUE RIVER HYDROELECTRIC PROJECT

Interest Rate:	12%
Total Project Cost:	$5,941,800
Annual Debt Service:	726,700
Annual Operation and Maintenance:	48,000
Total Annual Cost:	774,700
Production Cost, Mills/kWh:	67.4
Production Cost, $/kWh:	2,732
Power Value, Mills/kWh:	66
Benefit/Cost Ratio:	1.68

TABLE VII-6

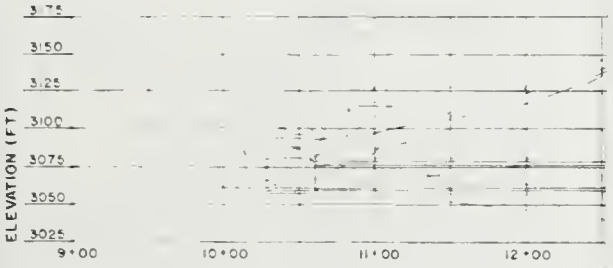
DISSOLVED OXYGEN AND TEMPERATURE
STANDARDS FOR THE TONGUE RIVER

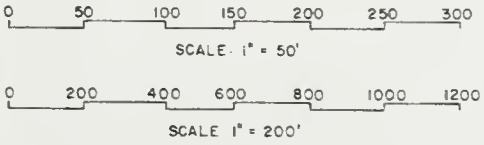
Parameter	Standard
Dissolved Oxygen	• Cannot be less than 7.0 mg/l from October 1 to June 1.
	• Cannot be less than 6.0 mg/l from June 2 to September 30.
Temperature	• No more than 1 degree increase when the water temperature is 32 to 77oF.
	• Cannot exceed 67oF when the water temperature is 66 to 66.5oF.
	• No more than a 0.5 degree increase when the water temperature is above 66.5oF.
	• No more than a 2 degree decrease per hour when the water temperature is above 55oF.
	• Cannot decrease more than 2 degrees when the water temperature is 55 to 32oF.



GENERAL PLA

SCALE: 1" = 200'





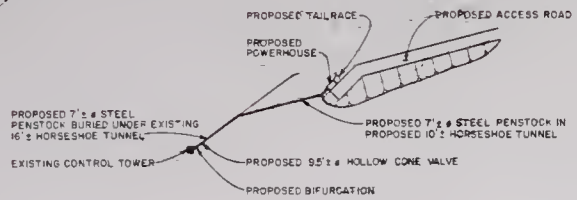
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

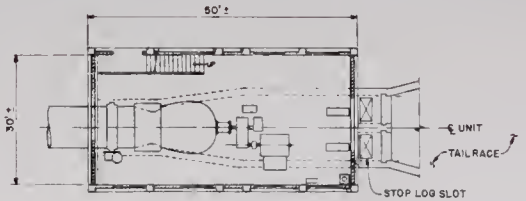
MONTANA HYDROELECTRIC RECONNAISSANCE

TONGUE RIVER HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

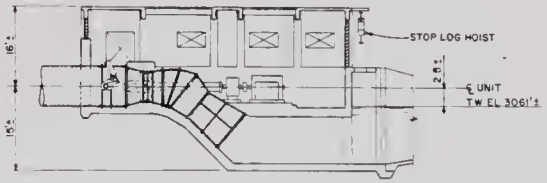
FIGURE VII-1


PROPOSED TAILRACE
PROPOSED ACCESS ROAD
PROPOSED POWERHOUSE
PROPOSED 7'± ø STEEL PENSTOCK BURIED UNDER EXISTING 16'± HORSESHOE TUNNEL
PROPOSED 7'± ø STEEL PENSTOCK IN PROPOSED 10'± HORSESHOE TUNNEL
EXISTING CONTROL TOWER
PROPOSED 9.5'± ø HOLLOW CONE VALVE
PROPOSED BIFURCATION



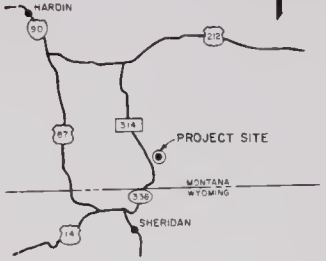
PLAN
NOT TO SCALE

LOCATION MAP



SECTION ALONG CENTEPLINE OF POWERHOUSE
NOT TO SCALE

TONGUE RIVER

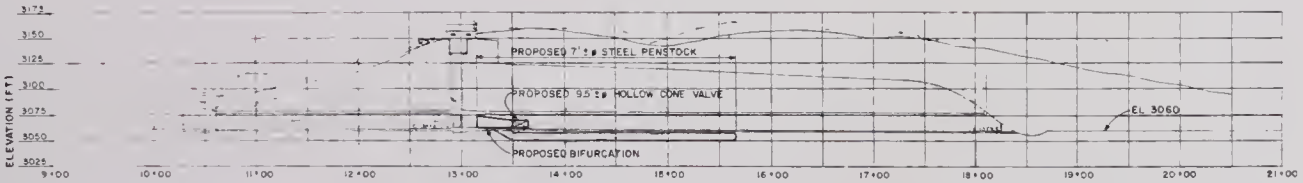


VICINITY MAP

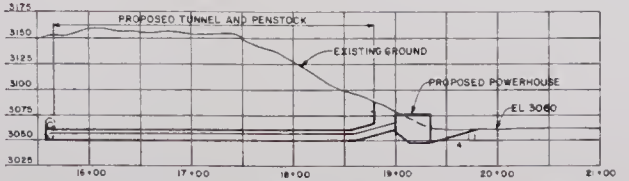
PROJECT DATA
TONGUE RIVER HYDROELECTRIC PROJECT

Turbine Type:	Tubular
Turbine Capacity:	2,177 hp (one unit)
Rated Head	55 ft
Rated Flow	550 cfs
Average Annual Energy:	11.5 GWh

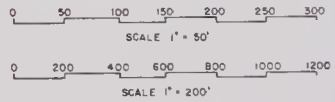
GENERAL PLAN
SCALE 1" = 200'



PROFILE ALONG CENTERLINE OF OUTLET WORKS
SCALE 1" = 50'



PROFILE ALONG CENTERLINE OF 10' DIAMETER HORSESHOE TUNNEL AND POWERHOUSE
SCALE 1" = 50'



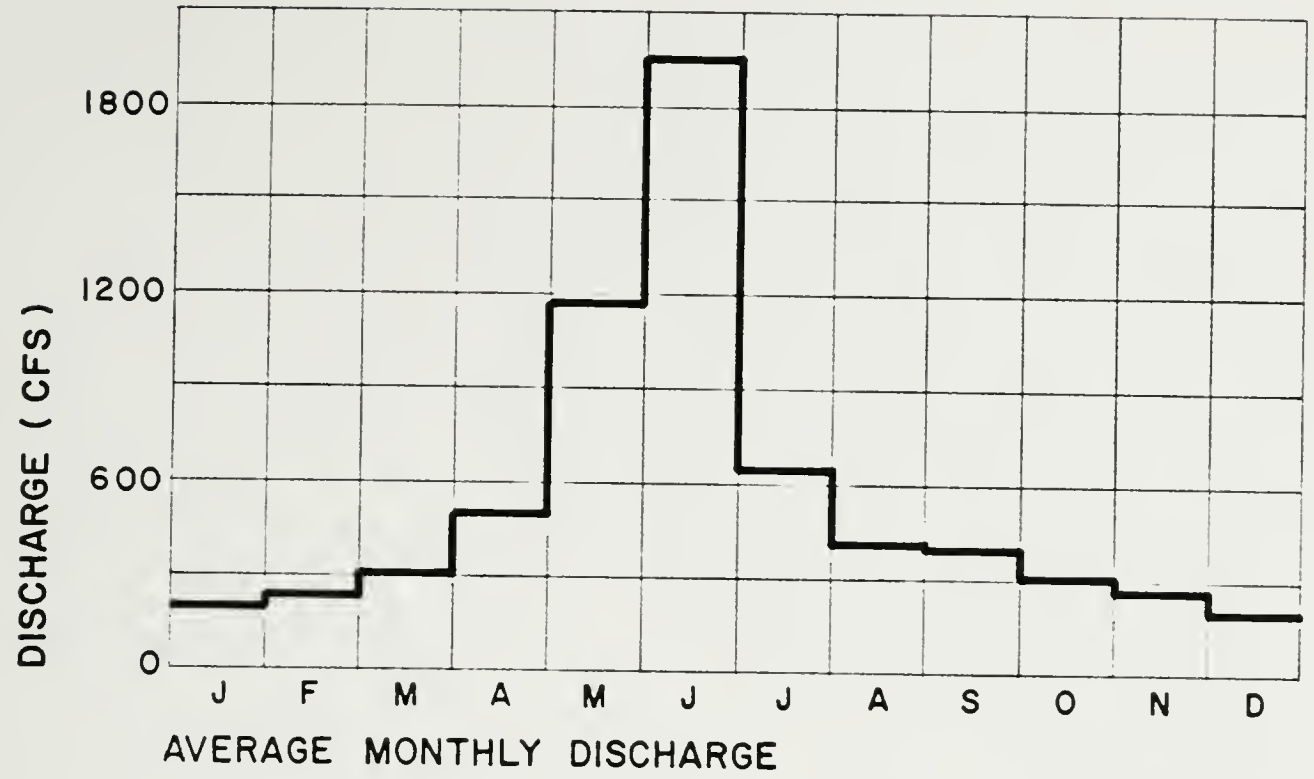
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

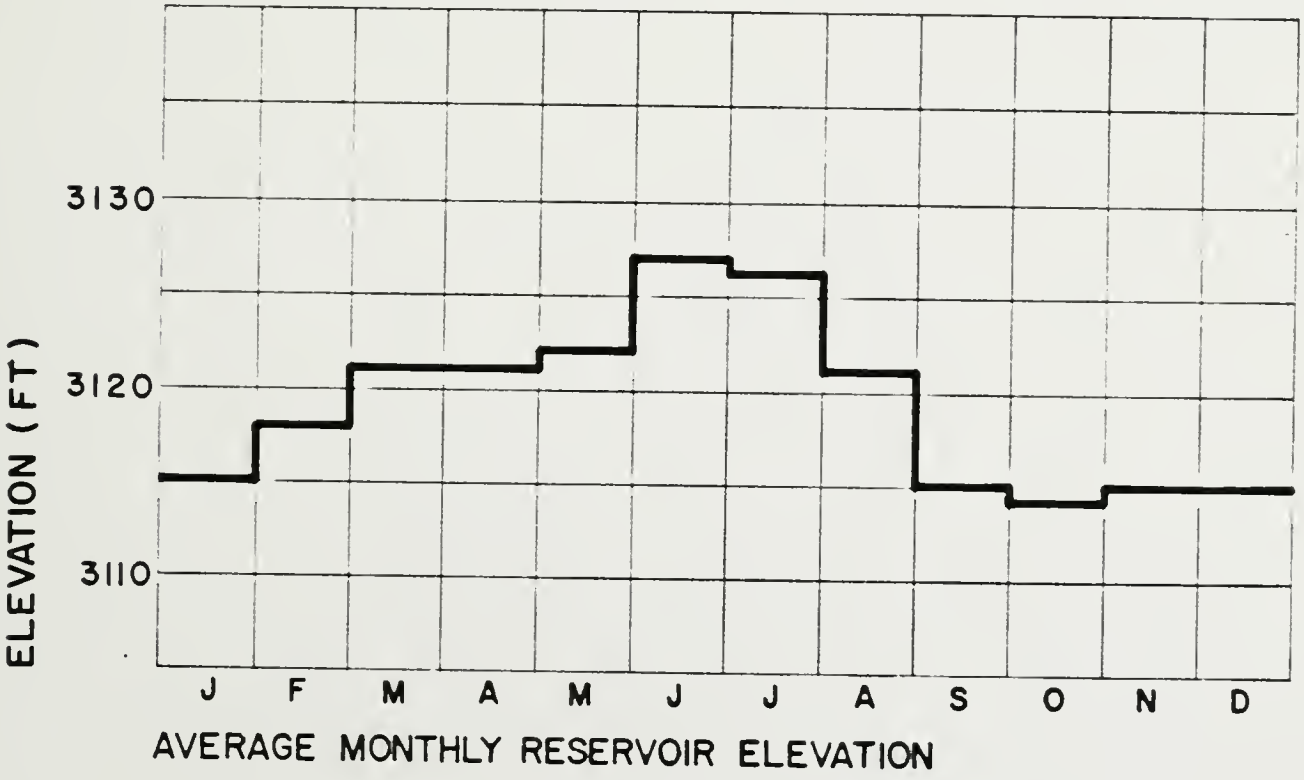
TONGUE RIVER HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

FIGURE VII-1



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

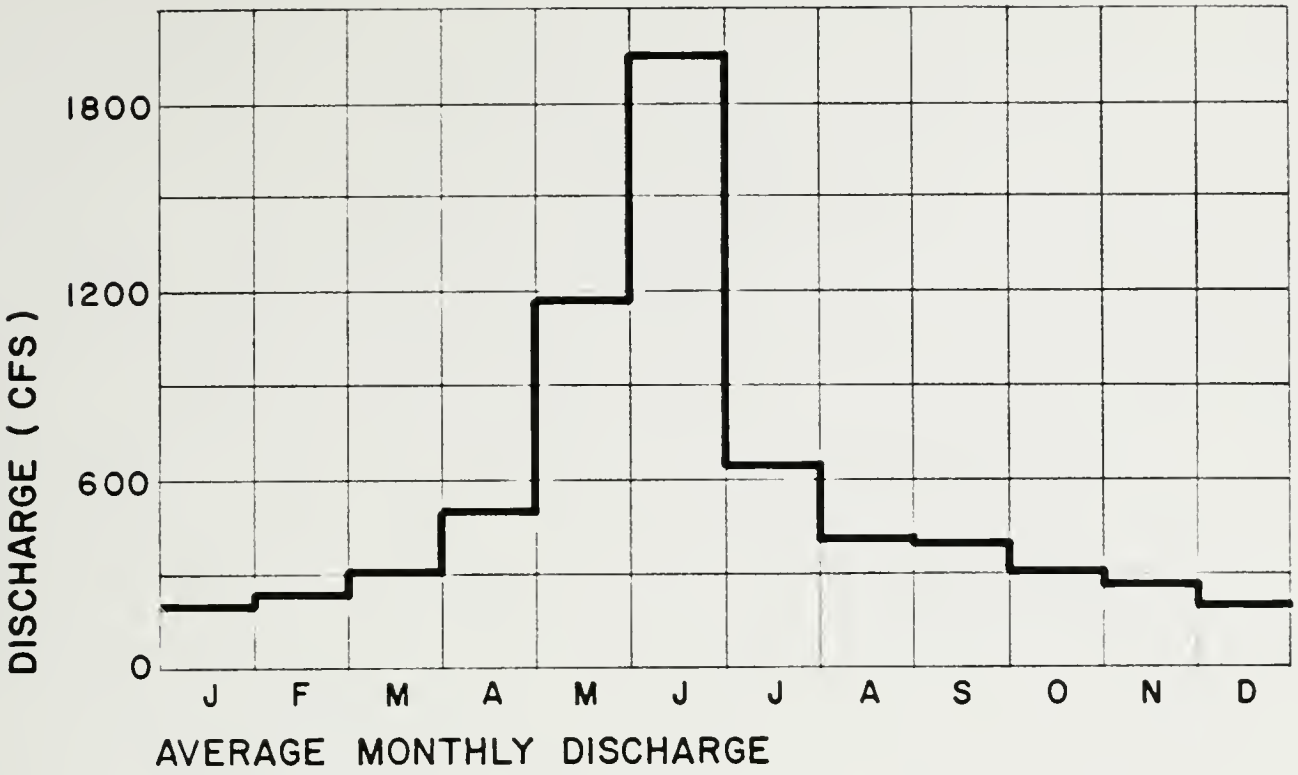
STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

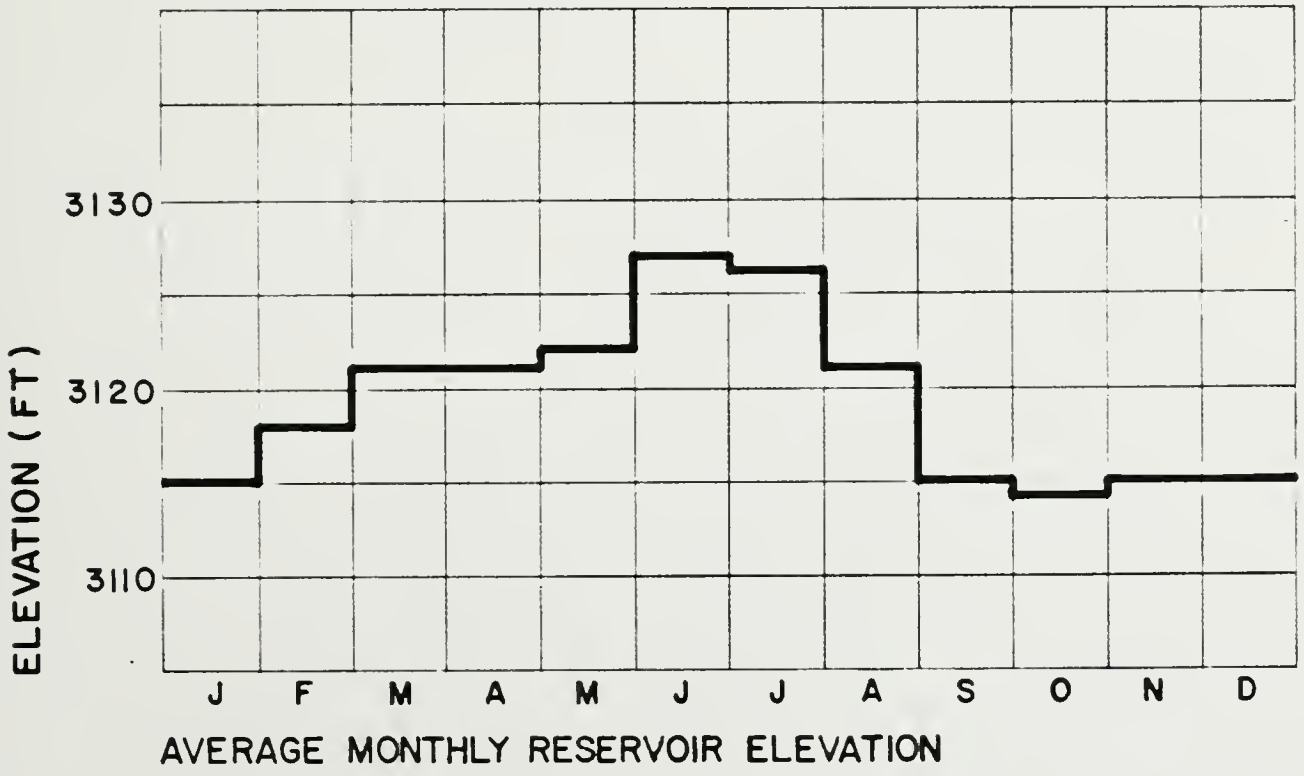
TONGUE RIVER DAM

FIGURE

VII-2



AVERAGE MONTHLY DISCHARGE



AVERAGE MONTHLY RESERVOIR ELEVATION

STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

TONGUE RIVER DAM

FIGURE

VII-2

DEADMAN'S BASIN, LOOKING UP PROPOSED PENSTOCK ROUTE

DEADMAN'S BASIN IN AREA OF PROPOSED INTAKE

SECTION VIII
DEADMAN'S BASIN HYDROELECTRIC PROJECT

A. GENERAL

The Deadman's Basin Hydroelectric Project would be located on the Musselshell River below Deadman's Basin, an offstream irrigation storage facility 22 miles east of Harlowtown in Wheatland County, Montana. The reservoir impounded by the dam is used primarily for irrigation storage; however, recreational uses are also benefits associated with the existing project. The proposed project would utilize flow releases that currently pass through the existing outlet works to produce approximately 8.6 million kilowatt-hours of electrical energy annually.

B. EXISTING FACILITIES

The main features of the Deadman's Basin Project are the supply canal, the reservoir, the dikes that impound the reservoir, the existing outlet works, and the Barber and Careless Creek Canals. Additional existing features significant to the development of a hydroelectric project include access to the site and the existence of electrical transmission lines. The existing facilities are described in more detail below. The arrangement of the facilities is shown on Figure VIII-1.

1. Supply Canal

The Deadman's Basin Supply Canal diverts water from the Musselshell River to Deadman's Basin. The capacity of the canal is 600 cfs. The canal is 11.3 miles long.

2. Dam

The main dam at Deadman's Basin, and the existing outlet works, will not be affected by the proposed project. The

intake for the proposed project will be located on an 18 foot high earthfill dike southwest of the main dam. The dike is 2,950 feet long with a crest width of 15 feet. The fill was placed on a 2:1 slope on the downstream face; the upstream face is at 2:1 below normal pool elevation and 3:1 above normal pool elevation. The top of the dike is at elevation 3,932.8 feet and the normal pool elevation is 3,915.9 feet.

3. Site Access

An existing dirt road currently provides access to the crest of the dike. A paved road currently provides access to the proposed power house site. These roads would provide adequate access to the powerhouse location for construction, operation, and maintenance of the project.

4. Transmission Lines

During the June 5, 1982 field trip to the Deadman's Basin site, major transmission lines were observed within 500 feet of the proposed powerhouse location. It is anticipated that transmission lines with adequate capacity for the transmission of power from the Deadman's Basin Project exist in the immediate area of the project. The project is in the Montana Power Company service area. For purposes of estimating the project cost, it has been assumed that it will be necessary to construct only a short interconnection to an existing line. Because of the limited amount of time that was available for the conduct of this study, adequate data to determine the exact nature of the interconnection were not obtained. This data should be determined as part of a detailed feasibility study of the proposed project.

C. PROPOSED PROJECT

The Deadman's Basin Project would use the drop between the reservoir and the Musselshell River to generate power. The project as proposed herein would operate for about eight months out of the year, from mid-April to mid-December. Winter operation was avoided because of possible problems associated with ice. A substantial increase in energy would be possible if the project is operated during the winter; however, the layout might require modifications for year round operation.

1. Project Description

An intake with trashracks would be constructed on the upstream side of the dike with an invert elevation of 3,872 feet. The intake would deliver the flow to a 51 inch diameter concrete conduit placed through the dike; this conduit would be about 1,300 feet long. A gate house with a butterfly valve would be built at the downstream end of the concrete conduit. Downstream from the gatehouse, 2,600 feet of 51 inch diameter steel penstock would deliver the flow to a reinforced concrete powerhouse containing a 1600 kW horizontal Francis turbine. The powerhouse would be equipped with a hollow cone low flow bypass valve with an energy dissipation chamber. The powerhouse would discharge to a tailrace that would pass through a culvert under the existing road and railroad tracks and return the flow to the Musselshell River.

2. Hydrology and Hydraulics

Deadman's Basin, an offstream storage reservoir, stores water diverted from the Musselshell River, which is a tributary to the Missouri River system. Deadman's Basin is located in Wheatland County, about 6 miles east of Shawmut and about 20 miles east of Harlowton. Diversions from the river to Deadman's Basin are made through the Deadman's Basin Supply

Canal. The intake to the Supply Canal is located on the Musselshell River at river mile 303.7. The Supply Canal is approximately 11.3 miles long and has a hydraulic capacity of 600 cfs. Diversions from Deadman's Basin back into the river have historically been made through two irrigation canals; the Barber Canal and Careless Creek Canal. The Barber Canal is approximately 3 miles long, and empties into the Musselshell River at river mile 285.3. Some irrigation demands are met by the Barber Canal. The Careless Creek Canal joins Careless Creek about 7.3 miles downstream of Deadman's Basin. Careless Creek rejoins the Musselshell River about 15.5 miles downstream of the Canal, at river mile 266.1. Additional irrigation needs are met by the Careless Creek Canal. See Figure VIII-1 for a plan of the Deadman's Basin canal system.

The historical operation of Deadman's Basin is reflected by several stream gages. The flow in the Musselshell River at the intake of the Supply Canal can be estimated based on three U.S. Geological Survey (USGS) stream gages. Stream gage records are available for gage 06120500, "Musselshell River at Harlowton, MT" from October 1906 to September 1981. This gage is located about 20 miles west of Deadman's Basin and the total drainage area above the gage is 1,125 square miles. A main tributary to the Musselshell River upstream of Deadman's Basin, and not reflected in the USGS gage at Harlowton, is gage 06122000. "American Fork below Lebo Creek, near Harlowton, MT". The drainage area above this gage is 166 square miles. The drainage area above Deadman's Basin Supply Canal diversion is 1,504 square miles. The above two gages have a total drainage area of 1,291 square miles, which is about 86 percent of the total drainage area above Deadman's Basin. In order to get a reasonable estimate of the Musselshell River flows at the Supply Canal intake, the USGS stream gage 06123500 "Musselshell River near Ryegate, MT" located at about river mile 268 and 2 miles upstream of the mouth of Careless Creek, was used to verify the estimated flows. The following table summarizes the results:

Gage	Years of Record	Average Discharge (AF/yr)	Drainage Area (sq. mi.)	Elevation of Gage (ft.)
Musselshell R. at Harlowton	1906-1981	118,800	1,125	4,160
American Fork below Lebo Cr.	1945-1967	22,440	166	4,170
Total	-	141,240	1,291	-
Musselshell R. near Ryegate	1947-1978	133,300	1,979	3,600

From the above table, it can be seen that the combined flow from the Musselshell River at Harlowton, and the American Fork below Lebo Creek gages account for about 106 percent of the flow at the Musselshell River near Ryegate gage. It is estimated that about 20,000 AF of Musselshell River flow is diverted around the Musselshell River near Ryegate gage. It is estimated that about 20,000 AF of Musselshell River flow is diverted around the Musselshell River near the Ryegate gage, via Careless Creek. (See the following text for more information). With this adjustment, the combined flow from the Harlowton and American Fork gages accounts for about 92 percent of the flow in the Musselshell River at the confluence with Careless Creek. The total drainage area at this location is about 2,010 square miles, or 30 percent more than at the reservoir site. Therefore, the estimated historical average monthly Musselshell River flow at the Supply Canal intake is taken as the sum of the flows at the Harlowton and American Fork gages for the period of record of 1962 through 1976. The average estimated discharge in the Mussellshell River at the Supply Canal intake for the 15 years of record is within 10 percent of the long-term average.

Four stream gages, all maintained by the Montana Department of Natural Resources and Conservation (DNRC) are located on the Deadman's Basin canal system. They are as follows:

Gage	Period of Record	Recorded Average Discharge
40A 08000 Deadman's Basin Supply Canal below headgate near Shawmut, MT.	1961-1976	41,600 AF/season
40A 08080 Deadman's Basin Supply Canal above reservoir near Shawmut, MT.	1962-1976	30,900 AF/season
40A 09000 Careless Creek Canal below reservoir near Shawmut, MT.	1962-1976	24,800 AF/season
40A 10000 Barber Canal below headgate near Shawmut, MT.	1962-1976	16,600 AF/season

The daily canal flow records are kept on a seasonal basis, with no flow information available typically from October through April each year. This accounts for the apparent discrepancy where the outflow from Deadman's Basin, measured at the Careless Creek and Barber Canal gages, appears to exceed the inflow, measured at the Supply Canal above reservoir gage, by about 10,500 AF per season. In order to reflect the total inflow into Deadman's Basin, the 10,500 AF of unmeasured inflow was assumed to occur at a constant rate of 25 cfs from October through April. This base flow of 25 cfs during October through April was added to the historical average monthly inflow to the reservoir.

The water surface level in the reservoir is recorded by DNRC gage 40A 08900, "Deadman's Basin Reservoir." Records have been maintained for this reservoir since June 1941. The maximum observed reservoir contents during the long-term period of record were 73,240 acre-feet in June 1978, and the minimum content was 3,290 acre-feet in October 1961. The total usable storage available in the reservoir is 72,220 acre-feet between the bottom of the outlet elevation 3,872 feet, and the maximum design elevation 3,921 feet. The dead storage, below elevation 3,872 feet, is 4,600 acre-feet.

The historical average inflow to the reservoir and the flows available for power production at Deadman's Basin were estimated based on the following criteria:

a. The minimum allowable monthly flow in the Musselshell River, downstream of the Supply Canal intake, was limited to the historical minimum monthly flow recorded at the Musselshell River near Ryegate gage. See Table VIII-2 for the monthly flows.

b. The "excess" river flows, which could be diverted into Deadman's Basin are estimated to be the average monthly river flows at the intake to Supply Canal minus the minimum historical river flows near Ryegate, up to the canal capacity of 600 cfs.

c. The required irrigation releases to the Careless Creek Canal are based on 1,500 acres of land irrigated at a rate of 1.6 acre-feet of water per acre of land per year, or 2,400 acre-feet of water per year.

d. The required irrigation releases to the Barber Canal are based on 400 acres of land irrigated at a rate of 1.6 acre-feet of water per acre of land per year, or 640 acre-feet of water per year.

e.The percent of irrigation water needed per month is: 12% in May, 18% in June, 32% in July, 27% in August, 11% in September, and no irrigation is needed from October through April. Table VIII-2 also summarizes the irrigation demands.

f. The maximum amount of flow available for power production is estimated to be the excess river flows minus the required irrigation flows.

For the purposes of estimating this site's potential installed capacity, power production, and energy production, the historical records of the reservoir elevations for the years 1962 through 1976, and the aforementioned adjusted maximum inflow were used to develop an average monthly record of water surface elevations, and an annual hydrograph of average monthly flows. These values are shown graphically on Figure VIII-2.

3. Power Study

The average annual hydrograph and average record of monthly water surface elevations described above were used to estimate the installed capacity and annual average energy production for the Deadman's Basin Project. This determination was made based on typical turbine performance characteristics and the physical characteristics of the site. The head available for power production was estimated as the difference between the headwater and tailwater elevation minus an allowance for head losses. The capacity of the plant was not optimized; however, an attempt was made to select the turbine so that its operation would encompass as wide of a variation in the available head and flow as possible.

A horizontal Francis turbine with a rated head of 130 feet, rated flow of 170 cfs, and rated capacity of 1,600 kilowatts was selected for the Deadman's Basin site. The turbine would produce power for eight months from mid-April to mid-October during an average year and would produce approximately 8.6 million kilowatt-hours annually. The average annual plant factor for the site would be about 61 percent.

Possible year-round operation of the power project was considered during this study. If the project were operated for 12 months, in an average year it would produce 12.0 million kilowatt-hours and have an average plant factor of 86 percent.

However, winter operation of the project could pose a number of serious problems, including damage to the supply canal and its structures, damage to the power plant intake, and flooding due to ice jams. It may be possible to mitigate these problems by a variety of measures that could include maintaining constant flow and water surface elevations throughout the canal and reservoir system, strategic location of ice booms, submergence of structures, and heating of structures. Possible winter operation of the project should be considered as part of a more detailed feasibility study.

4. Cost Estimate

The total project capital cost consists of the direct construction cost; the associated indirect costs for engineering, management and administration; and interest during construction. This cost estimate is based on bid prices for similar construction work, recent manufacturers quotes for mechanical and electrical equipment, and experience with other projects. The estimate also includes allowances for contingencies and for the costs of engineering. The contingency allowance is 15 percent of the mechanical and electrical costs plus 20 percent of all other costs. The engineering costs cover activities which include detailed feasibility studies, obtaining miscellaneous licenses and permits, final design, contract plans and specifications, and engineering services during construction. This amount was estimated as 25 percent of the direct construction cost plus contingencies. An allowance was also made for owner administration, financial, and legal expenses. Interest during construction was based on an 18-month construction period and 12 percent interest. No allowance was made for interest income from retained funds and the calculation of interest during construction is therefore very conservative.

The cost estimate is presented at July 1982 price levels. The estimated total project capital cost for the Deadman's

Basin Project is $3,775,800. The total project capital cost, escalated to the on-line date of July, 1984, would be $4,404,100. The cost estimate for the Deadman's Basin Project is presented as Table VIII-3 and the annual costs are summarized as Table VIII-4.

5. Economic Analysis

The benefits and costs associated with the Deadman's Basin Hydroelectric Project were assessed in order to determine the overall economic feasibility of the project. The project capital cost was escalated to July, 1984, at eight percent annual interest; this is the proposed bid date for the project. The value of power was escalated at ten percent annual interest to January 1986, the proposed on-line date for the project. It was assumed that the project would be financed with bonds having a life of 35 years and bearing a 12 percent interest rate. The cost of operation and maintenance for the first year of operation would be 1.25 percent of the capital cost plus contingencies.

It was assumed that the rate of general inflation is eight percent and that energy would escalate at ten percent annually. Inflation was considered for 10 years beyond the proposed on-line date of January 1986 and then held constant. All costs were discounted to January 1986 and the present worth of the benefits was compared to the present worth of costs to produce a benefit/cost (B/C) ratio for the project. The B/C ratio for this project is 1.69. The calculation of the B/C ratio is presented as Table VIII-5. This ratio indicates that the project is economically feasible.

D. ENVIRONMENTAL OVERVIEW

1. Overview

Deadman's Basin is an offstream storage reservoir located in the Musselshell River Basin, a tributary of the Missouri River. It is situated in a sagebrush-grassland area of low, rolling hills. The normal water surface elevation in the reservoir is 3,921 feet. It is operated to provide irrigation water with annual fluctuations from 76,900 to 30,000 acre-feet in volume. Recreation use of the reservoir for boating and fishing is substantial.

The reservoir supports an excellent fishery including crayfish, large brown trout and rainbow trout. The Department of Fish, Wildlife and Parks stocks the reservoir annually with between 250,000 and 500,000 rainbow trout (Markesan, pers. commun., 1982). The reservoir also provides fairly good waterfowl habitat (Markesan, pers. commun., 1982). Canada geese and ducks use the area extensively, particularly during the migration seasons of March through April and October to early December.

Although no information is available regarding the water quality of the reservoir, no particular problems are known to exist nor have any fish kills been reported there (Markesan, pers. commun., 1982). Continual high winds in the area have caused excessive erosion along the south shore of the reservoir. Ice covers the lake from late November or early December to March, April or May.

The proposed project will divert additional water from the Musselshell River to Deadman's Basin and return it to the river about 13 miles downstream after using the water to generate power. At the point of diversion, the river supports an excellent cold-water fishery of large brown and rainbow trout. From

that point downstream, the river is in transition to a warm-water fishery. The Department of Fish, Wildlife and Parks has been successfully stocking this 12-mile transition zone with smallmouth bass that feed on the abundant forage there. Riparian vegetation provides good cover along this stretch and the stream banks are stable. Below the discharge point from Deadman's Basin on the Musselshell River, a warmwater fishery predominates with sauger, channel catfish, and smallmouth bass the dominant game species.

Erratic releases of water from the reservoir have caused considerable erosion below the discharge point in the river. The fishery is poor at that point. The proposed project should stabilize the releases, thereby improving the fishery habitat.

The Water Quality Bureau of the Montana Department of Health and Environmental Sciences has classified the Musselshell River below Deadman's Basin as C-3. Dissolved oxygen and temperature standards for this classification are presented in Table VIII-7.

No flow has been reserved for fish and wildlife in the Musselshell River. For purposes of this study, the minimum allowable discharge in the Musselshell River was assumed to be equal to the historical minimum monthly flow. The Department of Fish, Wildlife and Parks has submitted a requested flow to the DNRC that ranges from a low of 59 cfs in January to a high of 531 cfs in June to flush the stream channel (Markesan, pers. commun., 1982). Although the Department has requested monthly flows, the DNRC will usually negotiate reserved rights based on a percentile flow.

Anchor ice is a problem on the Musselshell River. The city of Roundup floods nearly every spring as a result of ice jams on the river (Markesan, pers. commun., 1982).

2. Potential Problems

The environmental characteristics of the site suggest that some potential problems exist but that overall impacts will be minimal. Water levels in the reservoir should maintain fairly constant levels, close to those experienced in the past. The discharge point on the Musselshell River will be relocated about one mile upstream and will carry larger flows than in the past. The transmission line is expected to be less than one mile long.

Increased inflows and outflows in the reservoir will increase flushing and decrease retention time. This may in fact improve the fishery habitat by upgrading water quality and increasing food supply in the reservoir. The program of stocking rainbow trout can continue unaffected. The increased flushing action, however, could cause additional erosion along the unstable south shore. Flushing action appears to have caused considerable erosion in the past. The system should be designed to direct flow of water toward the center of the reservoir rather than along the shoreline.

As discussed, from the diversion point to the discharge point on the Musselshell River, the stream is in transition from a cold water to a warm water fishery. With the diversion of additional water to Deadman's Basin for power production, this transition zone will probably shift upstream. At the same time, larger flows will be discharged to the Musselshell about one mile upstream from the current outlet for the Barber canal. Also, releases from the reservoir should be less erratic than at present. Both of these changes should serve to improve fishery habitat in the Musselshell River below Deadman's Basin.

Some minimum flows were assumed for support of aquatic resources in the 12-mile stretch between the diversion and

discharge points on the Musselshell. The flows that would remain in the Musselshell River are the difference between the maximum flows available for power production and the actual flows used for power production from Table VIII-2. The success of these flows in sustaining fishery resources is not known.

Erosion below the new outlet works is also a concern. The stream banks are extremely susceptible to erosion. At the current site, for example, excessive erosion has degraded fishery habitat considerably.

Ice has been noted as a problem on the river. If winter operation of the power plant is planned, the outlet works and outflows must be designed to minimize such problems.

The project area is rich in cultural and historical resources. Although the transmission line is relatively short, an archeologic survey might be required before an exemption application can be filed. An archaeologic survey may also be required for the penstock route and powerhouse site.

3. Recommended Action

a. Minimum Streamflows. The DNRC should enter into discussions with the Department of Fish, Wildlife and Parks to reach agreement on the minimum flows required below the diversion on the Musselshell River. Because increased flows are being returned to the Musselshell at the new discharge point and because the reservoir will be flushed more quickly, the DNRC may want to study the tradeoffs afforded by the project before establishing a negotiating position.

b. Erosion Control. The DNRC should define the extent of the current erosion problems in Deadman's Basin and the Musselshell River. A special, more detailed study may be warranted to recommend specific design characteristics, opera-

tional changes, or control techniques to minimize expected problems.

c. Icing. The DNRC should initiate a study to determine the effects of the power plant operation on icing in the Musselshell River. Little is known about this problem and some changes to the design or operation of the facility may be required. Anchor ice is a major factor in flooding on the river, and a decrease in flow may intensify this problem. The power project as presented herein would not operate during the winter, and would not be likely to have much effect on icing. If year-round operation of the plant is practical, the overall feasibility of the project would be enhanced. Most important, the project must be shown to create no additional flooding problems on the river or acceptably minimize those problems.

d. Archeologic Survey. The DNRC should consult with the State Historic Preservation Officer to determine if an archeologic survey is warranted or required for the transmission line corridor. The survey should be conducted to identify any cultural or historical resources along the route and to determine what mitigation measures might be desirable.

E. CONCLUSIONS AND RECOMMENDATIONS

A hydroelectric project at Deadman's Basin would be technically, economically, and environmentally feasibile. The project would probably show a positive cash flow by 1987. Immediate implementation of the project is recommended. A detailed feasibility study should be conducted, and an Application for Exemption should be submitted to the Federal Energy Regulatory Commission.

TABLE VIII-1

MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF PHYSICAL FEATURES
DEADMAN'S BASIN

Turbine Type:	Horizontal Francis
Turbine Capacity:	1,600 kW (one unit)
Rated Head:	130 ft
Rated Flow:	170 cfs
Average Annual Energy:	8.6 GWh

TABLE VIII-2

FLOW SUMMARY

DEADMAN'S BASIN HYDROELECTRIC PROJECT

	Historical Estimated Avg. River Flow at Canal Intake (cfs)	Minimum Musselshell River Flow Downstream of Intake (cfs)	Careless Creek Canal Flow		Barber Canal Flow		Maximum Flow Available For Power Production (cfs)	Estimated Actual Flow Used In Power Production (cfs)
			Historical Avg. (cfs)	Minimum Required (cfs)	Historical Avg. (cfs)	Minimum Required (cfs)		
JAN	79	7	-	-	-	-	72	-
FEB	94	9	-	-	-	-	85	-
MAR	133	17	-	-	-	-	116	-
APR	197	18	6	-	-	-	179	135 3/
MAY	517	46	24	5	10	1	465	135
JUN	782	76	53	7	37	2	591 1/	137
JUL	242	70	122	13	83	3	156	135
AUG	131	30	142	11	96	3	87	130 2/
SEP	103	5	57	4	44	1	93	127 2/
OCT	103	3	2	-	2	-	100	127 2/
NOV	101	11	-	-	-	-	90	120 2/
DEC	95	9	-	-	-	-	86	111 2/ 3/
Totals (AF):	155,500	18,200	24,800	2,440	16,600	640	127,600	62,600

1/ Flow limited by Supply Canal capacity.
2/ Portion of outflow released form reservoir storage.
3/ Power production possible for half month only.

TABLE VIII-3

MONTANA HYDROELECTRIC RECONNAISSANCE
PROJECT CAPITAL COSTS
DEADMAN'S BASIN

	Item	Cost
1.	Structures and Improvements	289,700
2.	Reservoirs, Dams and Waterways	1,142,000
3.	Turbines and Generators	376,000
4.	Accessory Electrical Equipment	200,000
5.	Miscellaneous Mechanical Equipment	15,000
6.	Switchyard	35,000
7.	Transmission Lines	0
	Direct Construction Cost	2,057,700
	Contingencies	380,200
	Subtotal	2,437,900
	Engineering (25%)	609,500
	Subtotal	3,047,400
	Administrative, Legal, and Financial (5%)	152,400
	Subtotal	3,199,800
	Interest During Construction	576,000
	TOTAL PROJECT CAPITAL COST (July 1982)	3,775,800
	TOTAL PROJECT CAPITAL COST (Escalated to July 1984 at 8% compounded annually)	4,404,100

TABLE VIII-4

ESTIMATED ANNUAL COST
DEADMAN'S BASIN HYDROELECTRIC PROJECT

1.	Total Project Capital Cost escalated to July, 1984		$4,404,100
2.	Estimated Cost of Capital:	12%	
3.	Economic Life of Project:	50 Years	
4.	Annual Costs		
	4.1 Amortization Cost 1/		538,600
	4.2 O, M & R 2/		35,500
			$ 566,900
5.	Estimated Average Annual Generation		
	8,590,000 kWh/Annum		
6.	Unit Cost of Power		

$$\frac{\$\ 566,900}{8,590,000} \times 1,000 = 66.0 \text{ mills/kWh}$$

1/ Amortized for 35 years at 12 percent.

2/ 1.25 percent of Capital Cost plus contingency, escalated to July, 1984.

TABLE VIII-5

Benefit/Cost Analysis - Tudor Engineering Company

DEADMAN S BASIN HYDROELECTRIC PROJECT - STATE OF MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

JULY 1982

Year	Cost Streams		Benefit Stream (*)	Present Worth Factor (*)	Present Worths	
	Debt Service	O&M&R (*)			Cost	Benefit
1986	538600	35500	566900	1.00000	574100	566900
1987	538600	38300	623600	0.89286	515100	556800
1988	538600	41400	686000	0.79719	462400	546900
1989	538600	44700	754600	0.71178	415200	537100
1990	538600	48300	830100	0.63552	373000	527500
1991	538600	52200	913100	0.56743	335200	518100
1992	538600	56300	1004400	0.50663	301400	508800
1993	538600	60800	1104800	0.45235	271200	499800
1994	538600	65700	1215300	0.40388	244100	490800
1995	538600	71000	1336800	0.36061	219800	482100
1996	538600	71000	1336800	0.32197	196300	430400
1997	538600	71000	1336800	0.28748	175200	384300
1998	538600	71000	1336800	0.25668	156500	343100
1999	538600	71000	1336800	0.22917	139700	306400
2000	538600	71000	1336800	0.20462	124700	273500
2001	538600	71000	1336800	0.18270	111400	244200
2002	538600	71000	1336800	0.16312	99400	218100
2003	538600	71000	1336800	0.14564	88800	194700
2004	538600	71000	1336800	0.13004	79300	173800
2005	538600	71000	1336800	0.11611	70800	155200
2006	538600	71000	1336800	0.10367	63200	138600
2007	538600	71000	1336800	0.09256	56400	123700
2008	538600	71000	1336800	0.08264	50400	110500
2009	538600	71000	1336800	0.07379	45000	98600
2010	538600	71000	1336800	0.06588	40200	88100
2011	538600	71000	1336800	0.05882	35900	78600
2012	538600	71000	1336800	0.05252	32000	70200
2013	538600	71000	1336800	0.04689	28600	62700
2014	538600	71000	1336800	0.04187	25500	56000
2015	538600	71000	1336800	0.03738	22800	50000
2016	538600	71000	1336800	0.03338	20300	44600
2017	538600	71000	1336800	0.02980	18200	39800
2018	538600	71000	1336800	0.02661	16200	35600
2019	538600	71000	1336800	0.02376	14500	31800
2020	538600	71000	1336800	0.02121	12900	28400
2021	0	71000	1336800	0.01894	1300	25300
2022	0	71000	1336800	0.01691	1200	22600
2023	0	71000	1336800	0.01510	1100	20200
2024	0	71000	1336800	0.01348	1000	18000
2025	0	71000	1336800	0.01204	900	16100
2026	0	71000	1336800	0.01075	800	14400
2027	0	71000	1336800	0.00960	700	12800
2028	0	71000	1336800	0.00857	600	11500
2029	0	71000	1336800	0.00765	500	10200
2030	0	71000	1336800	0.00683	500	9100
2031	0	71000	1336800	0.00610	400	8200
2032	0	71000	1336800	0.00544	400	7300
2033	0	71000	1336800	0.00486	300	6500
2034	0	71000	1336800	0.00434	300	5800
2035	0	71000	1336800	0.00388	300	5200
				Totals	5445700	9208900

Benefit/Cost Ratio = 9208900/5445700 = 1.69

* Note:

O&M&R Escalation Rate = 8 % for years 1 - 10
O&M&R Escalation Rate = 0 % for years 11 - 50

Power Revenue Escalation Rate = 10 % for years 1 - 10
Power Revenue Escalation Rate = 0 % for years 11 - 50

Discount Rate = 12 % for years 1 - 50

TABLE VIII-6

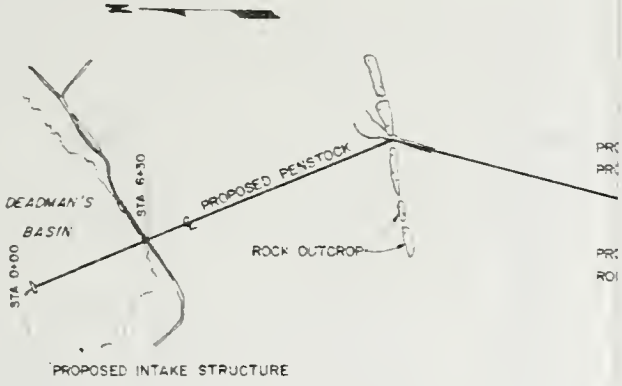
MONTANA HYDROELECTRIC RECONNAISSANCE
SUMMARY OF ECONOMIC FEATURES
DEADMAN'S BASIN HYDROELECTRIC PROJECT

Interest Rate:	12%
Total Project Cost:	$4,404,100
Annual Debt Service:	538,600
Annual Operation and Maintenance:	35,500
Total Annual Cost:	566,900
Production Cost, Mills/kWh:	66.0
Production Cost, $/kW:	2,752
Power Value, Mills/kWh:	66
Benefit/Cost Ratio:	1.69

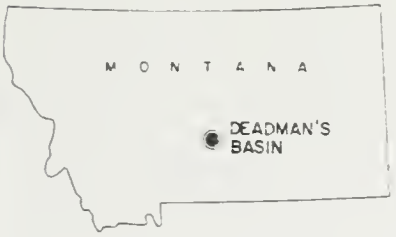
TABLE VIII-7

DISSOLVED OXYGEN AND TEMPERATURE
STANDARDS FOR THE MUSSELSHELL RIVER

Parameter	Standard
Dissolved Oxygen	• Cannot fall below 5 mg/l.
Temperature	• No more than 3 degrees increase when the water temperature is 32 to 77°F.
	• Cannot exceed 80°F when the water temperature is 77 to 79.5°F.
	• No more than a 0.5 degree increase when the water temperature is above 79.5°F.
	• No more than a 2 degree decrease per hour when the water temperature is above 55°F.
	• Cannot decrease more than 2 degrees when the water temperature is 55 to 32°F.

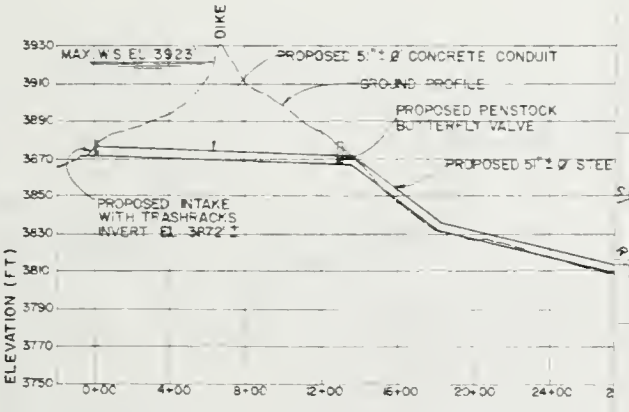


GENERAL PLAN
SCALE 1" = 400'



LOCATION MAP

VICINITY MAP



PROFILE
SCALE
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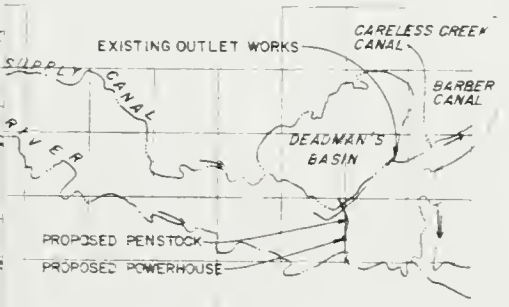
HORIZ 1" = 400'



ANAL SYSTEM PLAN

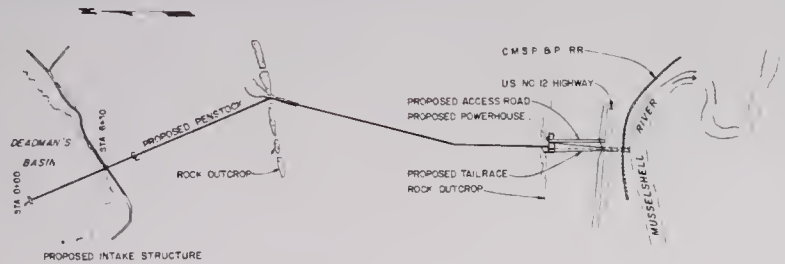
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

DEADMAN'S BASIN HYDROELECTRIC PROJECT

UDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

FIGURE VIII-1



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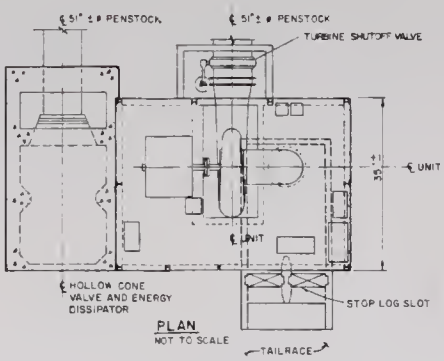
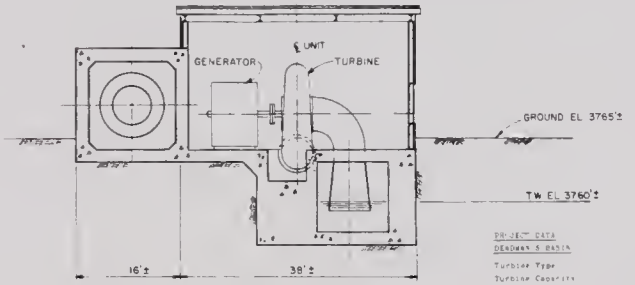
SCALE 1" = 400'



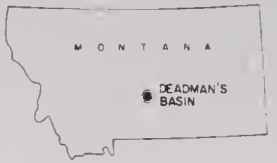
PLAN
NOT TO SCALE



SECTION ALONG CENTERLINE OF POWERHOUSE
NOT TO SCALE

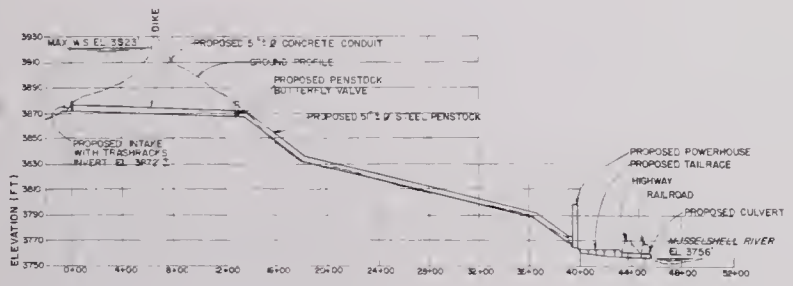
PROJECT DATA
DEADMAN'S BASIN

Turbine Type	Horizontal Francis
Turbine Capacity	1,600 ø one unit
Rated Head	130 ft
Rated Flow	70 cfs
Average Annual Energy	8.6 kWh

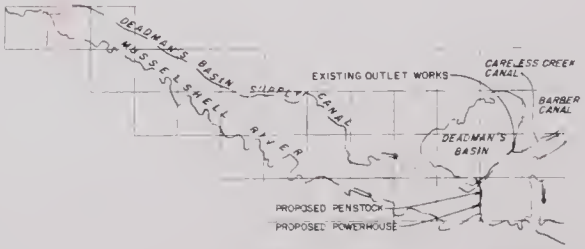


LOCATION MAP

VICINITY MAP



PROFILE
SCALE
VERT 1" = 40'
HORIZ 1" = 400'



CANAL SYSTEM PLAN

0 40 80 120 160 200 240
SCALE 1" = 40'

0 400 800 1200 1600 2000 2400
SCALE 1" = 400'

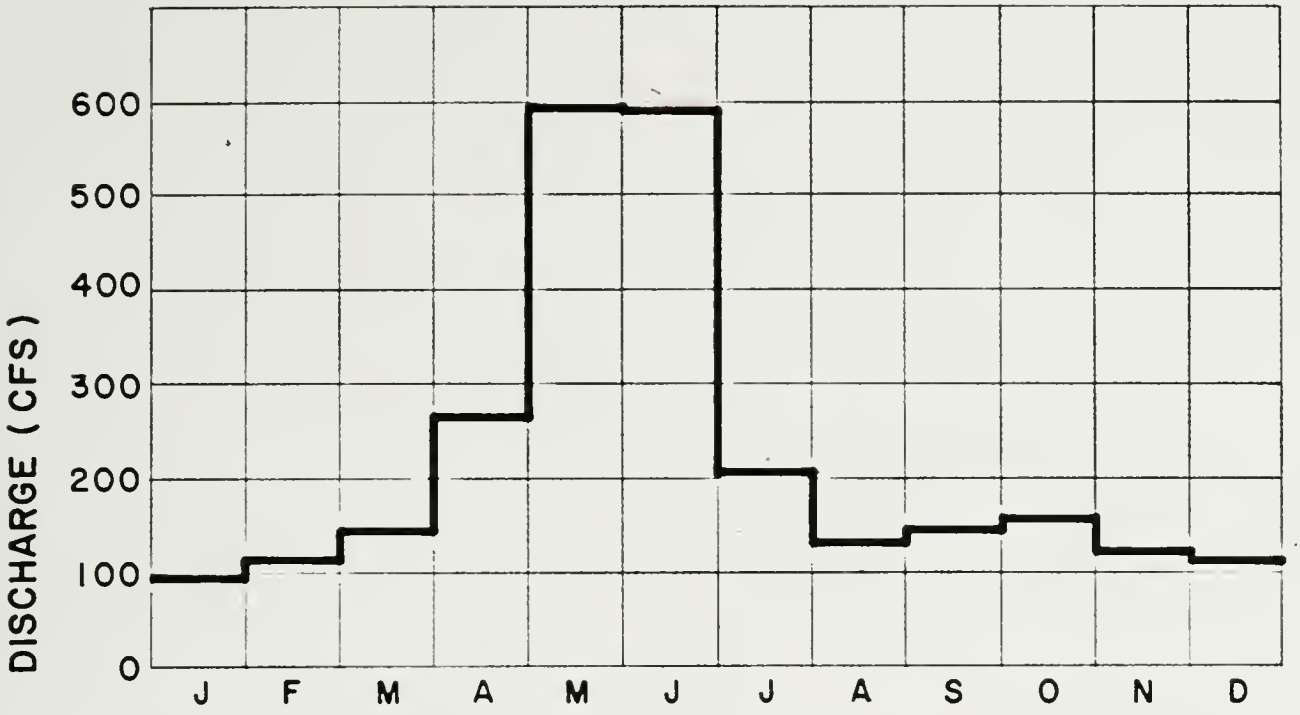
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

MONTANA HYDROELECTRIC RECONNAISSANCE

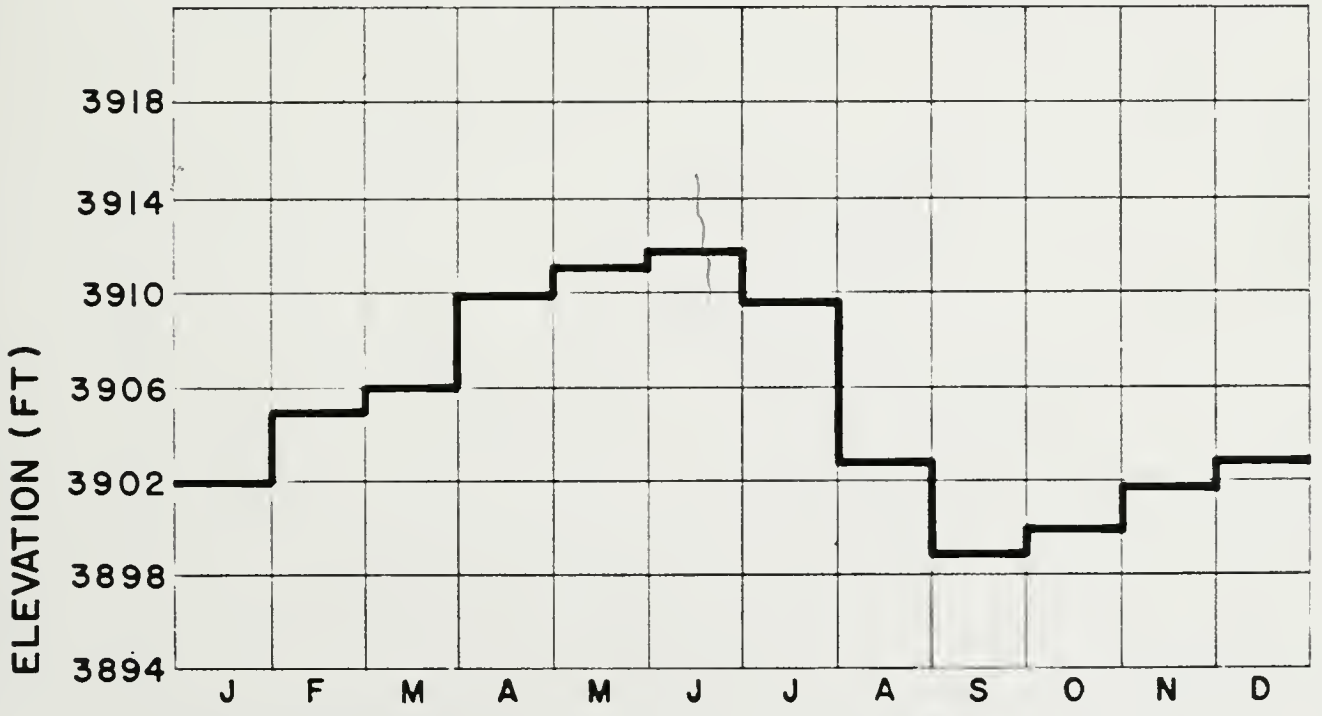
DEADMAN'S BASIN HYDROELECTRIC PROJECT

TUDOR ENGINEERING COMPANY SAN FRANCISCO, CALIFORNIA

FIGURE VIII-1



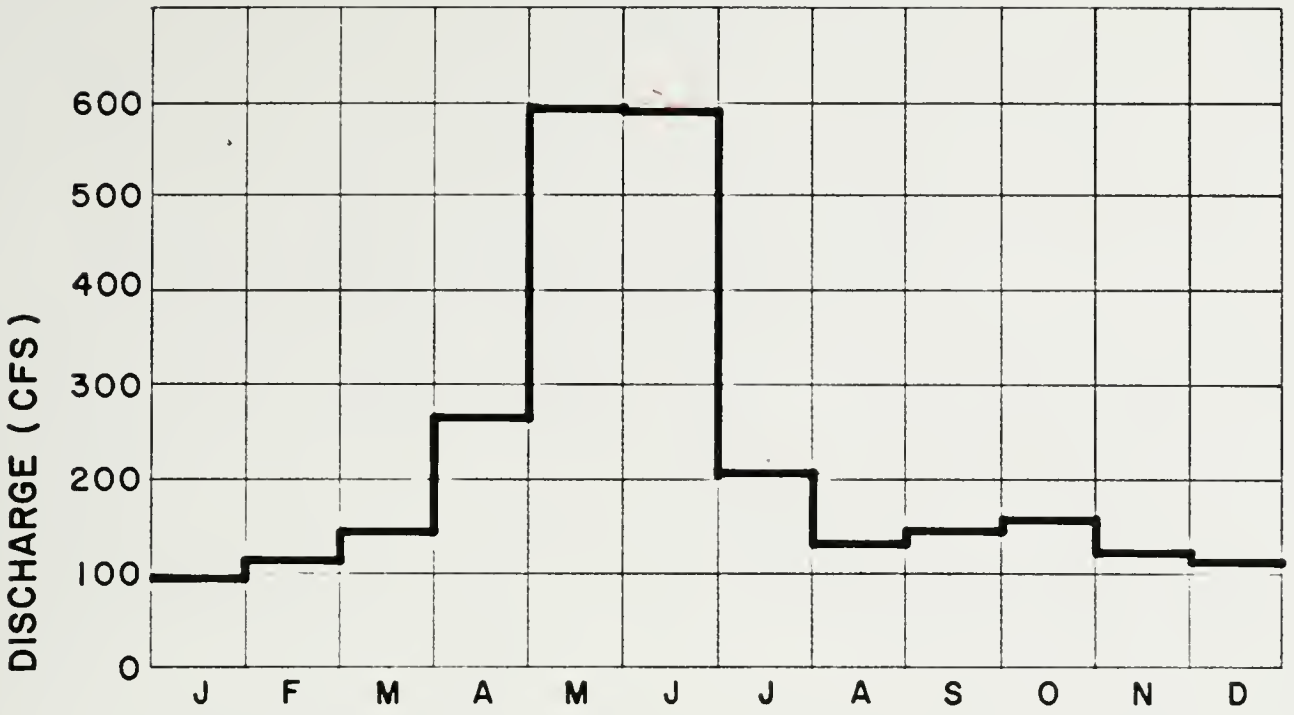
AVERAGE MONTHLY DISCHARGE
ADJUSTED FLOWS AVAILABLE FOR POWER PRODUCTION



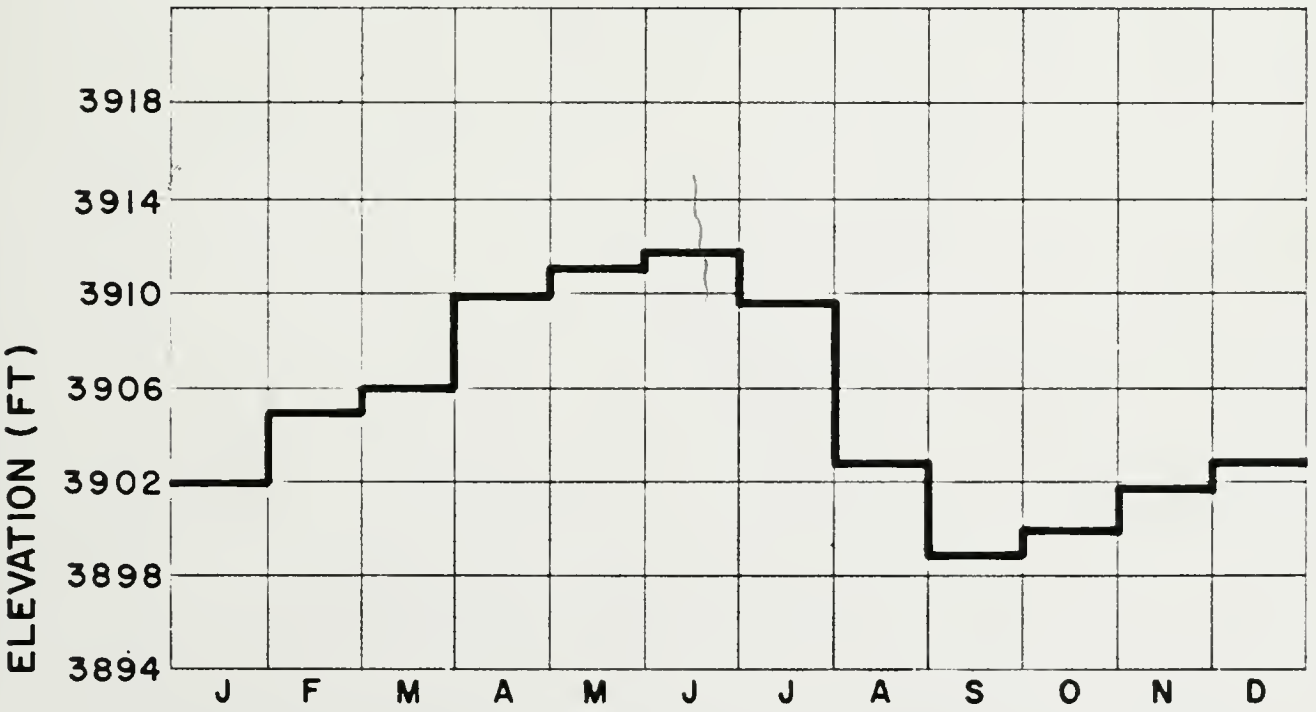
AVERAGE MONTHLY RESERVOIR ELEVATION

STATE OF MONTANA
MONTANA HYDROELECTRIC RECONNAISSANCE
DEADMAN'S BASIN

FIGURE
VIII-2



AVERAGE MONTHLY DISCHARGE
ADJUSTED FLOWS AVAILABLE FOR POWER PRODUCTION



AVERAGE MONTHLY RESERVOIR ELEVATION

STATE OF MONTANA
MONTANA HYDROELECTRIC RECONNAISSANCE
DEADMAN'S BASIN

FIGURE
VIII-2

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